INSTITUTE NOTES.

MAY, 1939.

STUDENTS' MEDAL AND PRIZE.

The Council has awarded the Students' Medal and Prize to V. G. NORRIS, Stud.Inst.Pet. (Birmingham University), for a thesis on "Porous Flow and its Application to Increased Recovery from Petroleum Reservoirs."

A Special Prize has also been awarded for the highly commended thesis of N. V. MUNSTER, Stud.Inst.Pet. (Birmingham University) on "Addition Agents for Lubricating Oils."

Conditions of 1939–1940 *Award.*

The Council has decided that the Students' Medal and Prize in 1939 will be awarded for a thesis on a set subject, and not for theses on subjects chosen by the candidates themselves.

A short list of alternative subjects on which theses are invited will be issued by the Council to all Students of the Institute after 30th June, 1939.

TRANSFERS TO NEW CLASSES OF MEMBERSHIP.

Members who wish to apply for transfer to one of the new classes of membership are requested to submit their applications as early as possible on the forms provided for the purpose at the back of the leaflet convening the Special General Meeting in January, 1939.

CANDIDATES FOR ADMISSION.

The following have applied for admission to the Institute or transfer to another grade of membership, and in accordance with the By-Laws the proposals will not be considered until the lapse of at least one month subsequent to the issue of this *Journal*, during which any Member or Associate Member may communicate by letter to the Secretary, for the confidential information of the Council, any particulars he may possess respecting the qualifications or suitability of any candidate.

The object of this information is to assist the Council in grading candidates according to the class of membership.

The names of the candidate's proposer and seconder are given in parentheses..

BANGERT, Norman Roy, Student (*Shell-Mex & B.P., Ltd.*), 26, Harrington Square, London, N.W. 1. (*J. Corthesy ; W. Wardlaw.*)

FORRESTER, Donald Stewart Rose, Engineer, c/o Soc. Unirea, Casuta Postala No. 1, Ploesti, Roumania. (*O. A. Bell ; C. G. Hitt.*)

FUSSTEIG, Rafael Simon, Consulting Engineer, Kraszewskiego 16, Jaroslaw, Poland.

MORGAN, Leo Clark, Geologist (*Morgan Acid Inc.*), 207, Ellis-Singleton Building, Wichita, Kansas, U.S.A. (*I. Gardescu ; W. W. Connor.*)

MORLEY, Ronald Herbert Henry, Chemist (*Asiatic Petroleum Company*), 8, Cartwright Gardens, London, W.C.1. (*J. Kewley ; W. W. Goulston.*)

PIZANTY, Mihail, Editor (*Moniteur du Petrole Roumain*), B-dul I.C. Bratianu, 26, Bucharest, Roumania. (*P. R. Clark ; L. Edeleanu.*)

RUTHRUFF, Robert Freeborn, Chemist, The M.W. Kellogg Co., 225 Broadway, New York, U.S.A. (*G. Egloff ; A. E. Dunstan.*)
SOPPET, Denis, Customs Officer, 118, Lansdowne Road, Worcester. (*A. R. Bowen.*)
WARD, John Thomas, Engineer (*M.W. Kellogg Co.*), 841, Cedar Terrace, Westfield, New Jersey, U.S.A. (*A. E. Dunstan ; F. B. Thole.*)

ARTHUR W. EASTLAKE,
Honorary Secretary.

ASPHALTIC BITUMEN GROUP.

A visit to the Road Research Station at Harmondsworth, Middlesex, has been arranged for Tuesday, 20th June, 1939. Members of the Asphaltic Bitumen Group and other members of the Institute who are desirous of participating in this visit should communicate as early as possible with the Honorary Secretary, Mr. C. E. Evans, c/o London and Thames Haven Oil Wharves, Ltd., Thames Haven, Essex.

Two meetings of the Group have been held since its inauguration in December 1938. Both meetings were held in the Institute's Library in The Adelphi. On 28th March, Mr. D. C. Broome gave a paper on "Measurement of the Flow Properties of Bitumen." Dr. A. R. Lee followed with an account of some of the work carried out at the Road Research Station on the same problem.

On 9th May, Mr. L. G. Gabriel gave a paper on "Bitumen Emulsions—Their Development and Present Sphere of Utility." Both these papers will be subsequently published in the Institute's *Journal*, probably in the August issue.

The following constitute the Committee of the Asphaltic Bitumen Group :

J. S. JACKSON, B.Sc., F.I.C. (*Chairman*).
C. E. EVANS, B.Sc., A.I.C. (*Hon. Secretary*).
D. C. BROOME, F.C.S., M.Am.Chem.Soc.
F. H. GARNER, Ph.D., M.Sc., F.I.C.
R. PRESTON, M.Sc., A.I.C.

Members of the Institute resident in Great Britain who are not yet registered for receipt of the notices relating to the Asphaltic Bitumen Group and who wish to be informed of its programme should communicate with the Honorary Secretary at the address given above.

WORLD AUTOMOTIVE CONGRESS.

Dr. A. E. Dunstan will represent the Institute at the World Automotive Congress in New York and Detroit from 22nd May to 2nd June, 1939. Dr. Dunstan will address a General Session of the Congress in New York on 22nd May on "To-day and To-morrow in Petroleum."

Mr. N. Mitchell, M.Inst.Pet., is the official delegate of the Institution of Automobile Engineers.

JOURNALS WANTED TO PURCHASE.

The Institute is prepared to purchase copies of the following issues of the Journal at the price of 10*s.* 0*d.* each :—

No. 1, June 1914
„ 19, April 1919
„ 31, April 1922

Journals should be forwarded to the Secretary, The Institute of Petroleum, The Adelphi, London, W.C. 2. Only copies in good condition will be considered for purchase.

PERSONAL NOTES.

Mr. R. CHANDLER has left for Bahrein Island.
Mr. F. E. J. FOXALL-SMEDLEY is home from Burma.
Mr. H. T. LORNE is returning to Iran.
Mr. C. V. RUTHERFORD is returning home from Iran.
Mr. L. A. WILSHERE has returned to Iran.

Correspondence or *Journals* forwarded to the following members have been returned, and the Secretary would be pleased to receive any information regarding their present address : G. E. BARBER, E. C. BROWN, K. BURTON, E. B. CHAPELLE, O. C. ELVINS, V. C. S. GEORGESCU, J. J. L. HAMILTON, J. R. HORTH, A. D. JONES, J. LANDER, H. R. LOVELY, I. LUSTY, F. MACKLEY, A. MACLEAN, G. P. MELVILLE, C. A. MOON, L. MOUNTFORD, S. NICOL, S. PAPP, R. G. REID, N. D. ROTHON, R. W. SMITH, H. G. SPEARPOINT, and P. F. THURLOW.

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NOTICES.

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Copyright.—Publication of abstracts of Papers and articles appearing in the Journal is permitted, provided that acknowledgment is made to the Institute of Petroleum.

Papers and Articles.—The Council invites Papers and Articles both for reading at Ordinary Meetings of the Institution and for publication in the *Journal*. All Papers, whether for reading or publication, will be submitted to a referee appointed by the Publication Committee.

The Institute has published a brochure "Instructions for the Guidance of Authors" containing details of recommended practice in the preparation of Papers for publication. Copies of this brochure will be supplied on request.

Pre-Prints.—Advance proofs of Papers to be read at Ordinary Meetings are generally available about a week before the Meeting. Members wishing to be supplied with these pre-prints are requested to notify the Secretary.

Abstracts.—Members and Journal Subscribers desirous of receiving the Abstracts printed on one side of the paper only, can be supplied with these at a charge of 10*s*. per annum per copy, payable in advance.

Issue of Journal.—Members whose subscription is not in arrear receive the *Journal* free of cost. A member whose subscription is not paid by March 31st of the year for which it is due is considered to be in arrear.

Changes of Address.—Members are requested to notify any change of address to the Secretary.

Benevolent Fund.—The Benevolent Fund is intended to aid necessitous persons who are or have been members of the Institute, and their dependent relatives.

The Fund is raised by voluntary annual subscriptions, donations, and bequests, and all contributions should be sent to the Secretary of the Institute at The Adelphi, London, W.C. 2. The Fund is administered by the Council through the Benevolent Fund Committee, and all applications in connection therewith must be made on a special form which can be obtained from the Secretary of the Institute.

Appointments Register.—A register of members requiring appointments is kept at the offices of the Institute, and every effort is made to assist members of the Institute in search of employment.

Members who desire their names and qualifications to be included in this register are requested to apply to the Secretary for the Form of Application for Registration, if they have not already done so. Members residing in the London area are asked, if possible, to return this Form in person and make themselves known, together with their requirements, to the Secretary. It is also requested that members should notify the Secretary immediately they have obtained an appointment.

In submitting names of candidates to prospective employers it is understood that the Institute accepts no responsibility and gives no guarantee.

Library.—The Institute's Library may be consulted between the hours of 9.30 a.m. and 5 p.m. daily. (Saturdays, 9.30 a.m. to 12 noon.)

Vol. 25. No. 187. May 1939.

RELATION BETWEEN MELTING POINT AND MOLECULAR WEIGHT IN THE *N*-PARAFFIN SERIES.*

By A. H. Etessam, B.Sc. (Student Member), and M. F. Sawyer, B.Sc. (Associate Member).

The relation between the melting point and number of carbon atoms in the molecule in a homologous series provides an interesting study, and it is therefore not surprising that attempts have been made to derive a formula expressing the melting point in terms of the number of carbon atoms in the molecule. The *n*-paraffin hydrocarbons, by reason of their many syntheses and the consequent accumulation of data, are particularly suitable for such a study, and some attention has been given to this series, which is of special interest to the Petroleum Industry.

The need for some relation which involved directly the melting point and molecular weight was mentioned by Austin[1] who, from certain theoretical concepts, deduced that for all homologous series these two properties are connected by the equation :—

$$\log M = A + \frac{4}{10^3} T,$$

where M = molecular weight, T = melting point in ° K. (Kelvin), and A is a constant, the value of which depends on the series. The relation, however, holds only roughly over a limited temperature range (250–330° K.).

From a knowledge of the heat of crystallization and setting point of the α-forms of four *n*-paraffins of comparatively high molecular weight (C_{22}, C_{26}, C_{30}, C_{34}), Garner, van Bibber and King[2] deduced the relation :—

$$T = \frac{(0{\cdot}6085n - 1{\cdot}75)}{(0{\cdot}001491n + 0{\cdot}00404)}$$

between the setting point T (in ° K.) and n, the number of carbon atoms in the chain. This equation, which gives a convergence temperature of 408° K., was used to calculate the setting point of the *n*-paraffin hydrocarbons from C_5H_{12} to $C_{70}H_{142}$. Agreement between experimental and calculated values is good for members above $C_{20}H_{42}$, but for *n*-paraffins of shorter chains the experimental value is always higher than the calculated value. The alternation in melting points between the odd and even paraffins of low molecular weight (see Fig. 1) was recognized by these authors, who suggested that the melting point of the members of this series cannot be represented by one equation, a suggestion confirmed by the alternation in the heats of crystallization of *n*-paraffins containing 5, 6, 7, and 8 carbon atoms.[3]

An attempt to find a more accurate relation has been made by Merckel,[4] who considers the odd and even members separately. For the odd series

* Paper received 9th March, 1939.

he finds that a linear relation exists between log T (melting point in ° K.) and the number $(n - 1)$ in the series such that

$$\log T = -\frac{2{\cdot}091}{n-1} + 2{\cdot}6018,$$

the two constants being calculated from the average of two known melting points. The difference between the experimental and calculated melting points for n-paraffins from C_{11} to C_{35} is not greater than 1° C. in any case, but considerable deviation is shown by the lower members of the series.

The even members fall into three groups :—

(*a*) Those above C_{22} which conform to the relation

$$\log T = -\frac{2{\cdot}284}{n-1} + 2{\cdot}6136,$$

good agreement being shown in the examples given to $C_{36}H_{74}$.

(*b*) Those from C_{10} to C_{22} (inclusive) which are in substantial agreement with the equation

$$\log T = -\frac{1{\cdot}870}{n-1} + 2{\cdot}5896,$$

the maximum deviation between observed and calculated values in this range being 1·8° K., and

(*c*) The members below C_{10} which deviate from this equation.

The convergence temperatures as given by the appropriate Merckel equations are 399·8° and 410·8° K. for the odd and even series, respectively.

Moullin,[5] by plotting $\log_{10}(n - 2)$ against the melting point (in ° C.) for n = 9–31 and 3–27, respectively, finds in each case that the points lie almost on a straight line, and concludes that the melting point T (in ° C.) and the number of carbon atoms, n, in the molecule are related by the equation :—

$$\log (n-2) = 1{\cdot}065 + \frac{5{\cdot}29}{10^3}\,T.$$

The agreement between the actual and the calculated melting points is, however, not very satisfactory.

This paper deals with an interesting and fundamental relationship between melting point and molecular weight in the n-paraffin series. In Fig. 1, curves *A* and *B* show, for the odd and even members, respectively, the melting point of the n-paraffin plotted against its molecular weight. Considerable choice in melting point is afforded by the literature for many members of the series, but the values used have been selected after careful consideration and, in the opinion of the authors, represent the most reliable figures.

It is evident from Fig. 1 that the odd and even members of the series lie on different curves, and it is therefore obvious that no one equation connecting melting point and molecular weight will suffice to represent to any degree of accuracy both the odd and even members over the whole

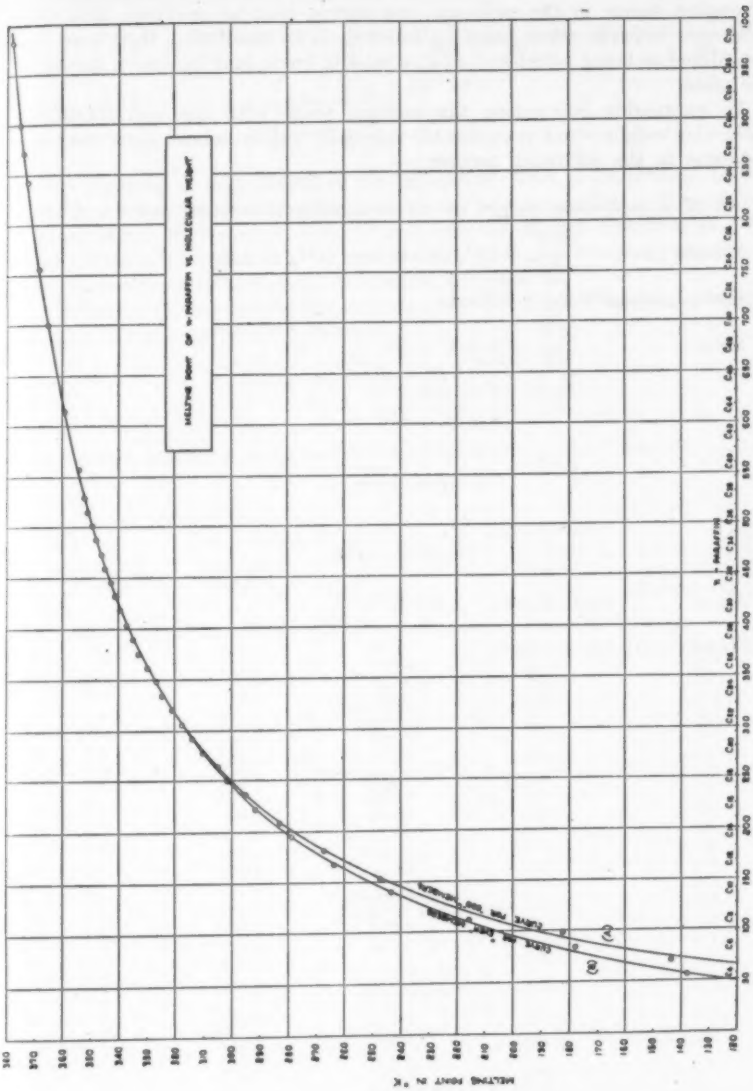
MELTING POINT OF n-PARAFFIN VS. MOLECULAR WEIGHT
MELTING POINT IN °K
MOLECULAR WEIGHT
n - PARAFFIN
(A)
(B)

FIG. 1.

series of n-paraffins. It is seen, however, that with increase in the number of carbon atoms in the molecule, the curves tend to converge, and the difference between them from C_{22} onwards is so small that they may be considered as being coincident—*i.e.*, a smooth curve may be drawn through the plots.

An expression connecting the melting point with the corresponding molecular weight which is applicable especially to this smooth curve may be obtained in the following manner:—

Let M = molecular weight of an n-paraffin of melting point = $T°$ K.

Assume $$\frac{dM}{dT} = k\phi^2, \text{ where } \phi = f(M) = aM + b$$

where k, a and b are constants.

Then $$\frac{dM}{dT} = k(aM + b)^2$$

$$\therefore \quad dT = \frac{1}{k}\frac{dM}{(aM + b)^2}$$

$$\therefore \quad \int dT = \int \frac{1}{k} \cdot \frac{dM}{(aM + b)^2}$$

i.e., $$T = -\frac{1}{ak} \cdot \frac{1}{(aM + b)} + \text{const.} \quad . \quad . \quad . \quad . \quad . \quad (1)$$

When $T = 0, M = 0, \therefore$ const. $= \frac{1}{akb}$

Equation (1) now becomes

$$T = \frac{1}{akb} - \frac{1}{ak} \cdot \frac{1}{(aM + b)}$$

$$= \frac{1}{akb}\left\{1 - \frac{1}{\frac{aM}{b} + 1}\right\}$$

$$= \frac{1}{akb} \cdot \frac{\frac{a}{b}M}{\frac{aM}{b} + 1}$$

$$= \frac{1}{akb} \cdot \frac{1}{1 + \frac{b}{aM}}$$

i.e., $$T = T_f \cdot \frac{1}{\left(1 + \frac{c}{M}\right)} \cdot \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

where T_f and c are both constant, being equal to $\frac{1}{akb}$ and $\frac{b}{a}$, respectively.

Equation (2) may be expressed in the form :—

$$T_f = T\left(1 + \frac{c}{M}\right) = T_{(x)}\left(1 + \frac{c}{M_{(x)}}\right) = T_{(y)}\left(1 + \frac{c}{M_{(y)}}\right)$$

from which

$$c = \frac{T_{(y)} - T_{(x)}}{\dfrac{T_{(x)}}{M_{(x)}} - \dfrac{T_{(y)}}{M_{(y)}}}$$

The constant c may therefore be calculated from a knowledge of the melting points and molecular weights of any two *n*-paraffins. The average figure of $c = 94{\cdot}4$ was obtained from a number of such calculations. By substituting this value of c in equation (2), T_f (which obviously represents the convergence temperature) is found to be 414·5° K.

Equation (1) connecting the melting point (T° K.) and molecular weight (M) of the *n*-paraffin then becomes :—

$$T = \frac{414{\cdot}5}{\left(1 + \dfrac{94{\cdot}4}{M}\right)} \text{ or } \frac{414{\cdot}5\,M}{(M + 94{\cdot}4)} \quad . \quad . \quad . \quad . \quad (3)$$

In Table I below are tabulated for the known *n*-paraffins, between C_{22} and

TABLE I.

Member of Series.	Molecular Weight.	Melting Point, ° K. (from Literature).	Melting Point, ° K. (from relation $T = \frac{414{\cdot}5M}{94{\cdot}4 + M}$).	Experimental — Calculated Melting Point.
C_{22}	310·4	317·5	317·9	−0·4
C_{23}	324·4	320·4	321·0	−0·6
C_{24}	338·4	324·1	324·1	±0·0
C_{25}	352·4	326·3	326·9	−0·6
C_{26}	366·4	329·6	329·6	±0·0
C_{27}	380·4	332·5	332·1	+0·4
C_{28}	394·4	334·6	334·5	+0·1
C_{29}	408·5	336·9	336·7	+0·2
C_{30}	422·5	339·0	338·8	+0·2
C_{31}	436·5	340·8	340·8	±0·0
C_{32}	450·5	342·6	342·7	−0·1
C_{33}	464·5	344·5	344·5	±0·0
C_{34}	478·5	345·8	346·2	−0·4
C_{35}	492·6	347·6	347·9	−0·3
C_{36}	506·6	348·8	349·3	−0·5
C_{37}	520·6	350·4	350·9	−0·5
C_{38}	534·6	352·2	352·3	−0·1
C_{39}	548·6	—	353·6	—
C_{40}	562·6	353·75 (±0·25)	354·9	−0·9
C_{44}	619·7	359·4	359·6	−0·2
C_{50}	702·8	365·1 (±0·2)	365·3	±0·0
C_{54}	758·9	368·0	368·7	−0·7
C_{60}	842·9	371·9 (±0·4)	372·8	−0·5
C_{62}	871·0	373·5	374·0	−0·5
C_{64}	899·0	375	375·1	−0·1
C_{70}	983·1	378·25 (±0·25)	378·2	±0·0

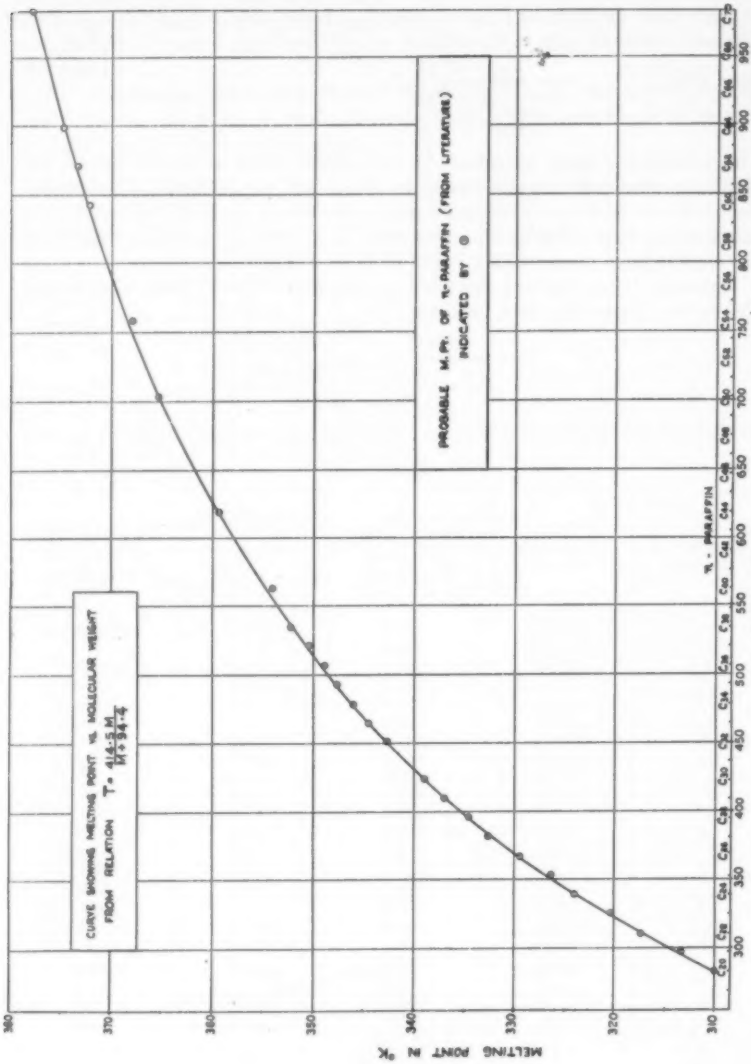
CURVE SHOWING MELTING POINT VS. MOLECULAR WEIGHT
FROM RELATION T = 414·5 M / M + 54·4
PROBABLE M.PT. OF n-PARAFFIN (FROM LITERATURE) INDICATED BY ⊙
MELTING POINT IN °K
MOLECULAR WEIGHT
n - PARAFFIN

FIG. 2.

C_{70} (*a*) the molecular weight, (*b*) the most reliable value of the melting point given in the literature, (*c*) the value of the melting point calculated from equation (3), and (*d*) the difference between the experimental and calculated figures.

A graphical representation of Table I is given in Fig. 2.

The difference between the experimental and calculated figures is

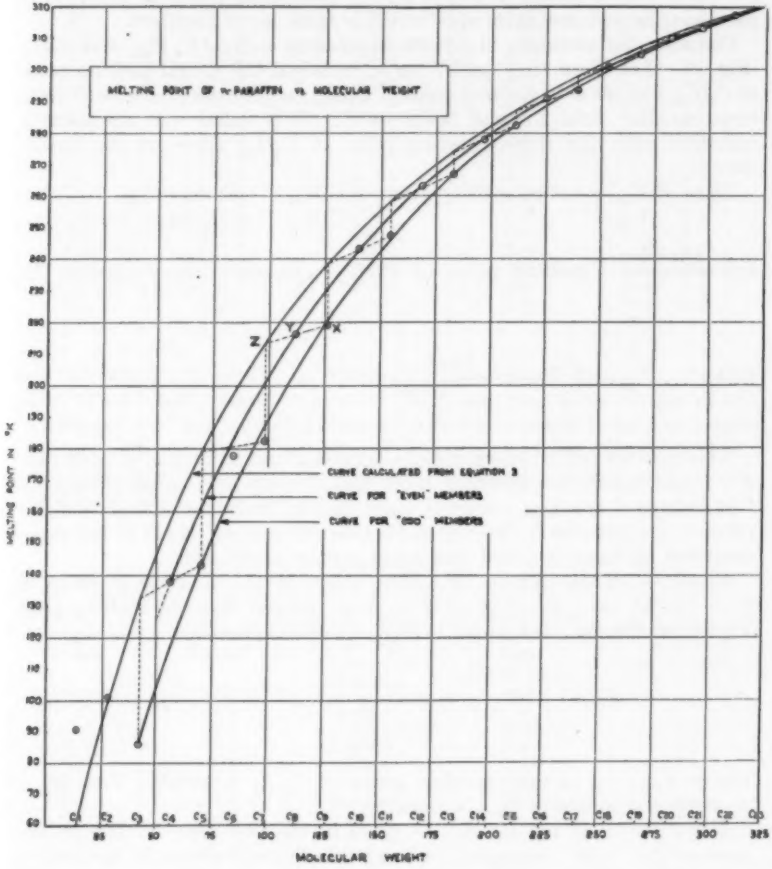

FIG. 3.

within 1° C. for all known members of the series having more than twenty-one carbon atoms in the molecule, and equation (3) may therefore be considered to represent the relation between melting point and molecular weight for the *n*-paraffins having molecular weight greater than 300.

With the lower members of the series, the difference between the actual values and those calculated from equation (3) in general increases with

decrease in the number of carbon atoms in the molecule, the difference being greater for the odd than for the even members, a fact well illustrated in Fig. 3, which shows the molecular weight and melting-point curve for this lower region drawn on a larger scale. Although the formula is not applicable with any degree of accuracy when the number of carbon atoms in the molecule is less than twenty-two, nevertheless there exists between the three curves shown in Fig. 3 a very interesting relation, which is of particular importance in its application to these lower members.

Consider, for example, the three *n*-paraffins C_7H_{16}, C_8H_{18} and C_9H_{20} (Fig. 3). Let X on the "odd" curve represent the actual melting point of C_9H_{20}, and let Z = melting point of C_7H_{16} on the curve calculated from equation (3). Join XZ and bisect at Y. It is found that the point Y coincides with the actual melting point of C_8H_{18} given on the "even curve."

Thus, if $T_{(9)}$ = actual melting point of C_9H_{20} ("odd curve")
$T_{(8)}$ = " " " " C_8H_{18} ("even curve")

and $\dfrac{414{\cdot}5}{1+\dfrac{94{\cdot}4}{M_{(7)}}}$ = melting point of C_7H_{16} calculated from equation (3)

then $$T_{(8)} = \tfrac{1}{2}\left\{T_{(9)} + \frac{414{\cdot}5}{1+\dfrac{94{\cdot}4}{M_{(7)}}}\right\} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

This relation (with two exceptions only) is found to be true in each case. For those members containing more than twenty-one carbon atoms the "calculated" curve is removed only slightly from the actual, and the relation is applicable to this region because the melting points of successive members increase by small and fairly regular increments.

Generally, if the number of carbon atoms in the molecule is given by $(n-1)$, (n), $(n+1)$, where n is an even integer, then the melting point $T_{(n)}$ of the "even" compound is given by the expression

$$T_{(n)} = \tfrac{1}{2}\left\{T_{(n+1)} + \frac{414{\cdot}5}{1+\dfrac{94{\cdot}4}{M_{(n-1)}}}\right\} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

where $T_{(n+1)}$ = actual melting point of $C_{(n+1)}$ *n*-paraffin, and $M_{(n-1)}$ = molecular weight of $C_{(n-1)}$ *n*-paraffin.

Using the most reliable figures given in the literature for the melting point of the "odd" *n*-paraffins (tabulated in Table I, column 3), the melting points of the "even" members have been calculated from equation (5). With two exceptions only (C_2 and C_6), the agreement between experimental and calculated values is within 1° C., as shown in Table II.

Equation 5 may be expressed in the form

$$T_{(n+1)} = 2T_{(n)} - \frac{414{\cdot}5}{1+\dfrac{94{\cdot}4}{M_{(n-1)}}}$$

TABLE II.

Member of Series.	Molecular Weight.	Melting Point, ° K. (from Literature).	Melting Point, ° K. (calculated from Equation 5).	Experimental — Calculated Melting Point.
C_2	30·0	101	73·0	+28·0
C_4	58·1	138·0	137·6	+ 0·4
C_6	86·1	177·6	180·9	− 3·3
C_8	114·1	216·2	216·4	− 0·2
C_{10}	142·2	243·3	242·1	+ 0·2
C_{12}	170·2	263·4	260·9	+ 0·5
C_{14}	198·2	278·5	278·6	− 0·1
C_{16}	226·3	291·1	291·0	+ 0·1
C_{18}	254·3	301·0	301·3	− 0·2
C_{20}	282·3	310·0	310·1	− 0·1
C_{22}	310·4	317·5	317·4	+ 0·1
C_{24}	338·4	324·1	323·7	+ 0·4
C_{26}	366·4	329·6	329·7	− 0·1
C_{28}	394·4	334·6	334·5	+ 0·1
C_{30}	422·5	339·0	338·8	+ 0·2
C_{32}	450·5	342·6	342·7	− 0·1
C_{34}	478·5	345·8	346·1	− 0·3
C_{36}	506·6	348·8	349·2	− 0·4

and obviously gives $T_{(n+1)}$, where $T_{(n)}$ is known—*i.e.*, the melting point of an "odd" member may be calculated from a knowledge of the melting point of the preceding "even" member and the molecular weight of the preceding "odd" member. With two exceptions only (C_3 and C_7) the agreement between experimental and calculated values is within 1° C., as shown in Table III below :—

TABLE III.

Member of Series.	Molecular Weight.	Melting Point, ° K. (from Literature).	Melting Point, ° K. (calculated from Equation 5).	Experimental — Calculated Melting Point.
C_1	16·0	90·4	—	—
C_3	44·1	85·9	141·8	−55·9
C_5	72·1	143·3	144·1	− 0·8
C_7	100·1	182·4	175·8	+ 6·6
C_9	128·2	219·3	219·0	+ 0·3
C_{11}	156·2	247·4	247·9	− 0·5
C_{13}	184·2	267·5	268·5	− 1·0
C_{15}	212·2	283·0	283·9	− 0·9
C_{17}	240·3	295·0	295·3	− 0·3
C_{19}	268·3	305·0	304·4	+ 0·6
C_{21}	296·3	313·4	313·1	+ 0·3
C_{23}	324·4	320·4	320·6	− 0·2
C_{25}	352·4	326·3	327·2	− 0·9
C_{27}	380·4	332·5	332·1	+ 0·4
C_{29}	408·4	336·9	337·1	− 0·2
C_{31}	436·5	340·8	341·3	− 0·5
C_{33}	464·5	344·5	344·4	+ 0·1
C_{35}	492·6	347·6	347·1	+ 0·5
C_{37}	520·6	350·4	349·7	+ 0·7

Summary.

1. The melting point of any normal paraffin having more than twenty-one carbon atoms in the molecule may be calculated from the relation :—

$$T = \frac{414{\cdot}5M}{M + 94{\cdot}4}$$

where T = melting point in ° K. of the n-paraffin of molecular weight = M.

2. From the relation :—

$$T_{(n)} = \tfrac{1}{2}\left\{T_{(n+1)} + \frac{414{\cdot}5\ M_{(n-1)}}{M_{(n-1)} + 94{\cdot}4}\right\}$$

where n = even integer
$T_{(n)}$ = melting point in ° K. of C_n n-paraffin
$T_{(n+1)}$ = " " " C_{n+1} "
$M_{(n-1)}$ = molecular weight of C_{n-1} "

the melting point of C_n may be calculated when the melting point of C_{n+1} is known, and vice versa.

With four exceptions only (C_2, C_3, C_6, C_7) the agreement between experimental and calculated values is within 1° C., and in this connection it will be noted from Fig. 3 that the reported values for C_6 and C_7 do not lie on the respective curves, and that the melting point of C_3 is abnormal, as it is lower than the melting points of C_1 and C_2.

The authors wish to express their appreciation to Dr. T. G. Hunter, of this Department, for his interest and encouragement in this research.

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University of Birmingham.

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THERMOMETRIC DETERMINATION OF TRANSITION POINTS IN PARAFFIN WAX.*

By H. D. Lord, Ph.D.

Synopsis.

It is shown that by the "inverse rate" method of plotting results it is possible to obtain transition points in paraffin wax conveniently and accurately. With an ordinary commercial wax containing a wide range of constituents of different melting points, the transition in crystalline form takes place slowly over a correspondingly wide range of temperature, but as the width of cut is reduced the transition range becomes narrower and more distinct, until for a narrow vacuum-fractionated wax it is quite marked and precise.

Figures for the fractionation of a white wax by sweating and by vacuum distillation are given, and it is shown that the differential between melting point and transition point of a paraffin wax decreases with increase in melting point and with narrowness of cut.

Thermal data for blends of 160 and 125/30 white waxes are included.

Mottling in wax is attributed to segregation of occluded air into the interstices between the crystal boundaries at the transition point.

Introduction.

It is a characteristic of many solid substances to change in crystalline form at a certain temperature or over a specific temperature range when heated or cooled. This change in structure is usually accompanied by evolution or absorption of heat and by change in physical properties, such as specific heat, conductivity, and coefficient of expansion; it is often possible by observation of these properties to determine the transition point with precision. Many investigations carried out have been mainly of purely academic interest, but highly important practical information has been obtained from the study of transition effects which occur in pure metals, and particularly alloys such as steels. In fact it may be truly said that almost all exact knowledge of the heat-treatment of steels depends on a knowledge of equilibrium diagrams constructed largely from transition-point data. Transition effects in paraffin wax are, of course, not nearly of such great moment, but they have attracted increasing attention during recent years, and many results of theoretical and practical importance have been obtained.

Transition Point of Paraffin Wax.

The transition point of a paraffin wax may be defined as that temperature at which its crystalline structure changes from a needle-like or α form to a plate or β form, with consequent evolution of heat and changes in physical properties such as density, coefficient of expansion, and air solubility. During this transition, wax, like other substances, is in a semi-amorphous condition, and it is obvious that this is of distinct importance if it is subjected in electrical or other industries to temperatures of this order.

* Paper received 10th February, 1939.

Crystalline Form.

The exact nature of the change in crystalline form at the α/β transition point is not known with certainty. The above statement that the phase stable immediately below the melting point crystallizes in the form of needles which change to plates at the transition point is based on microscopical evidence, and is in agreement with the views of certain other writers, particularly those of Yannaquis [1] and Katz.[2] There is not general unanimity of opinion on this point, however, and the writer has himself observed that in certain cases no clear-cut change in crystalline form can be observed when specific waxes are cooled under the microscope. In view of these considerations, and since the present paper deals almost solely with the thermometric method of determination of transition points and not with the actual structural changes involved, in future that phase stable immediately below the melting point will be referred to as α and that below the transition point or transition range as the β form.

With an ordinary commercial wax containing a wide range of constituents of different melting points, the transition in crystalline form takes place slowly over a correspondingly wide range of temperature, but as the width of cut is reduced the transition range becomes narrower and more distinct, until for a narrow vacuum-fractionated wax it may be quite marked and precise.

Previous Investigations on Determination of Transition Points in Paraffin Wax.

The presence of a transition point at a temperature about 15° C. below the melting point in a number of waxes has been established by several investigators. Carpenter [3] came to this conclusion as a result of microscopic evidence and a discontinuity in the curve relating the coefficient of expansion of waxes to temperature variation. Yannaquis [1] arrived at the same conclusion by observation of waxes under crossed nicols, and Piper [4] and also Müller [5] by X-ray determinations on pure paraffins and mixtures of paraffins.

Scott-Harley [6] has determined transition points thermometrically.

The experiments described in the present paper have been carried out independently of Scott-Harley's work and prior to the writing of his paper, which has been commented on privately, particularly with regard to (*a*) low thermal capacity of the small quantity of wax used compared with that of the apparatus, and (*b*) interpretation of results.

There is only a small amount of heat evolved at the transition point, but, as the present paper shows, it is possible, by using suitable apparatus and the "inverse rate" method of plotting results, to obtain quite accurate and reliable value thermometrically.

Experimental.

In experiments of the nature considered here, where one is trying to measure the effect of a small heat evolution, it is advisable to choose conditions to show up this effect to best advantage. It is necessary, for instance, to adjust the quantity of substance used so that in determining

a cooling curve the substance itself is the controlling factor and the apparatus has the least possible effect; that is why in metallurgical investigations of this sort a relatively large bar of material is used with apparatus of low thermal capacity. Since wax, however, unlike metals, has a low thermal conductivity, and it is inadvisable to have an appreciable temperature gradient throughout the cooling mass, the quantity of wax used in determining a cooling curve must of necessity be very much lower than in the case of metals.

It has been found that the normal I.P.T. Setting-Point apparatus for paraffin wax gives reliable cooling curves from which transition points can be readily ascertained. Accordingly this has been used throughout the present investigation, except that the thermometer has been replaced by a longer standard one graduated in tenths of a degree. With an optical attachment it was possible to read this thermometer to approximately the second place of decimals. Latterly, in experiments not reported, the jacket of the I.P.T. apparatus has been replaced by an open 1-gallon tin $9\frac{1}{2}$ in. $\times$ $5\frac{1}{2}$ in. $\times$ 5 in. high, fitted with a stirrer for more convenient control of water temperature; this does not affect the results obtained.

In all cases in determining a cooling curve the temperature of the cooling wax has been recorded every half-minute from about 5–10° C. above the melting point to approximately 20° C., the jacket temperature being maintained at $45 \pm 0{\cdot}2°$ F. From the primary cooling curves obtained, inverse rate curves have been plotted and transition points deduced as illustrated in the accompanying curves.

Inverse Rate Curves.

In this method, which has been used very successfully in metallurgical investigations, an ordinary cooling curve is first accurately determined, and the results are then plotted in the form of an inverse rate curve which accentuates any sign of heat evolution. This consists in plotting the time taken for the temperature to fall 1° (derived from the primary cooling curve) against the temperature at which this average time interval occurs, *i.e.*, $\frac{dt}{dT}$ = seconds per degree, against T (temperature). In order to get accurate values of $\frac{dt}{dT}$ it is necessary to plot the primary cooling curve on an open scale, and if the curvature is varying considerably, it is advisable to calculate $\frac{dt}{dT}$ from tangentials at the points in question.

The method can best be followed by reference to the accompanying curves.

In Fig. 1 *ABCDE* represents a primary cooling curve for a sample of commercial stearic acid which has a melting point similar to that of paraffin wax in common use, but no transition point. It was chosen because of this latter fact to illustrate the difference in inverse rate curves between such a substance and those of paraffin waxes in which transition takes place. The portion of the curve *AB* represents the cooling liquid and *BC* the melting or solidification point. For some time after point *C* is reached,

however, solidification still takes place, tending to keep up the temperature, but eventually, after solidification is complete, normal cooling results,

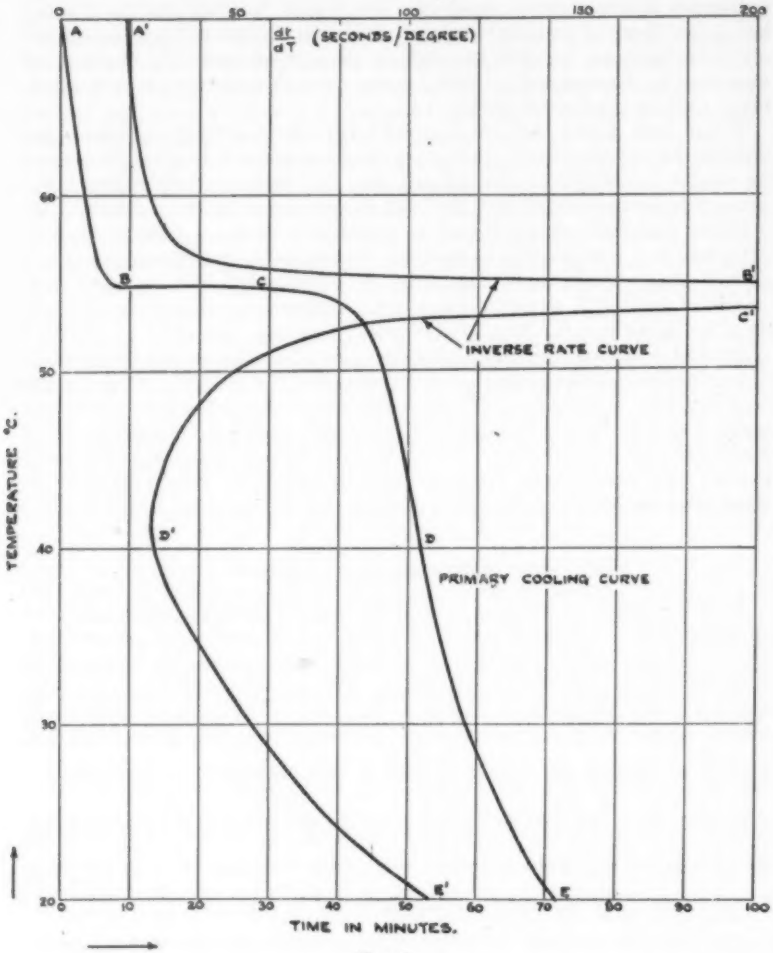

FIG. 1.

COOLING AND INVERSE RATE CURVES FOR COMMERCIAL STEARIC ACID. NO TRANSITION.

giving a curve DE with no further sign of heat evolution. As the rate of cooling of the liquid gradually falls along AB the function $\frac{dt}{dT}$ increases, as represented by the corresponding portion of the inverse rate curve $A'B'$.

Beyond B' $\frac{dt}{dT}$ increases still further, until at the melting point where dT is 0 it has a value of infinity. The curve $A'B'$ continued therefore approaches infinity, gradually reaching it eventually at the melting point.

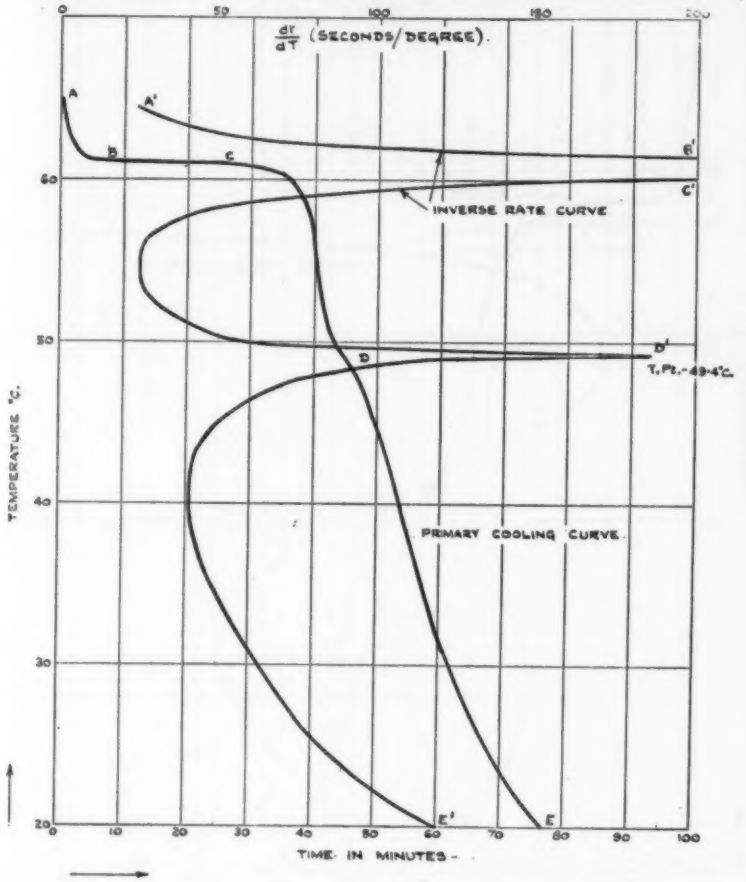

FIG. 2.

COOLING AND INVERSE RATE CURVES FOR NARROW-CUT WAX. SHOWING TRANSITION POINT.

Below the melting point, as the rate of cooling gradually increases the function $\frac{dt}{dT}$ shows a corresponding decrease from infinity to finite values C' and lower. The minimum point D' on the inverse-rate curve corresponds to the maximum rate of cooling D on the primary cooling curve

and the gradual increase of $\frac{dt}{dT}$ along $D'E'$ to the reduction in cooling rate along DE. The main point to notice is that for a substance showing no

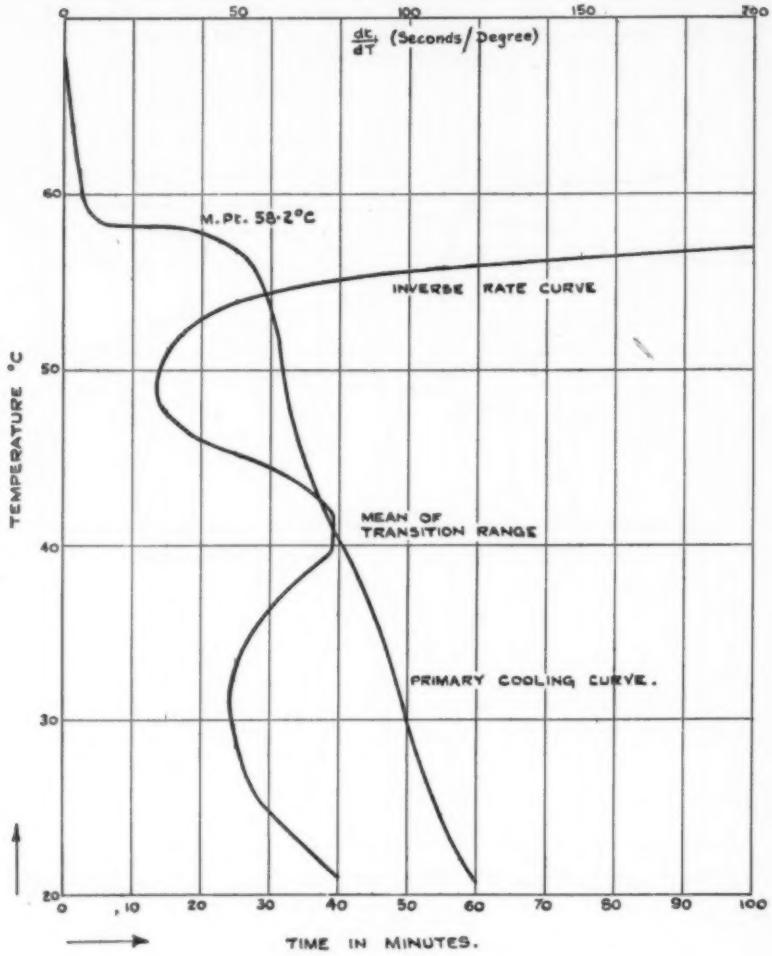

FIG. 3.

COOLING AND INVERSE RATE CURVES FOR 135/40 WAX.

transition point the portion of the inverse rate curve $C'D'E'$ below the melting point is quite smooth and regular, with no indication of abnormal thermal effects.

Turning now to Fig. 2 we have similar curves for a relatively close-cut

paraffin wax. In the primary cooling curve, after solidification is complete, there is a fairly pronounced kink at the point *D*, due to heat evolution taking place as a result of transition. Although this kink is fairly pro-

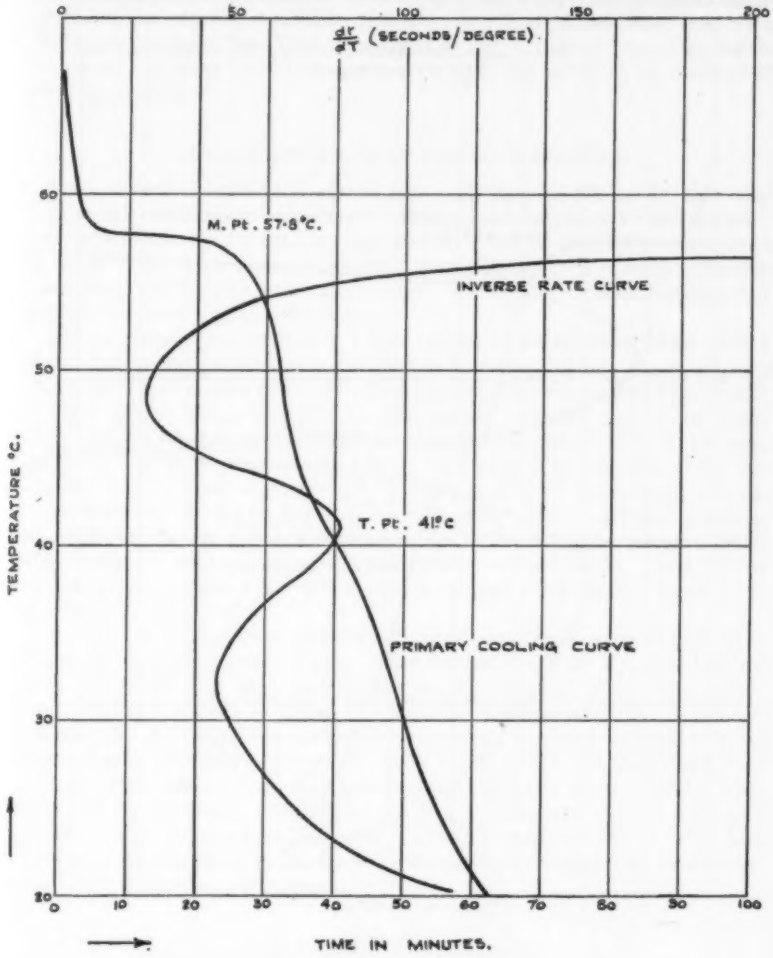

FIG. 4.

COOLING AND INVERSE RATE CURVES FOR 10TH FRACTION FROM SWEATING OF 135/40 WAX.

nounced, however, it is in no way comparable with the halt at the melting point, and does not afford a precise indication of the actual position of the transition point. This can, however, be determined very satisfactorily from the inverse rate curve. The reduction in cooling rate during tran-

sition has a very marked effect on the function $\frac{dt}{dT}$, which reaches a sharp maximum value at a point D' corresponding to the lowest rate of cooling, thus enabling the transition point to be determined with precision. It

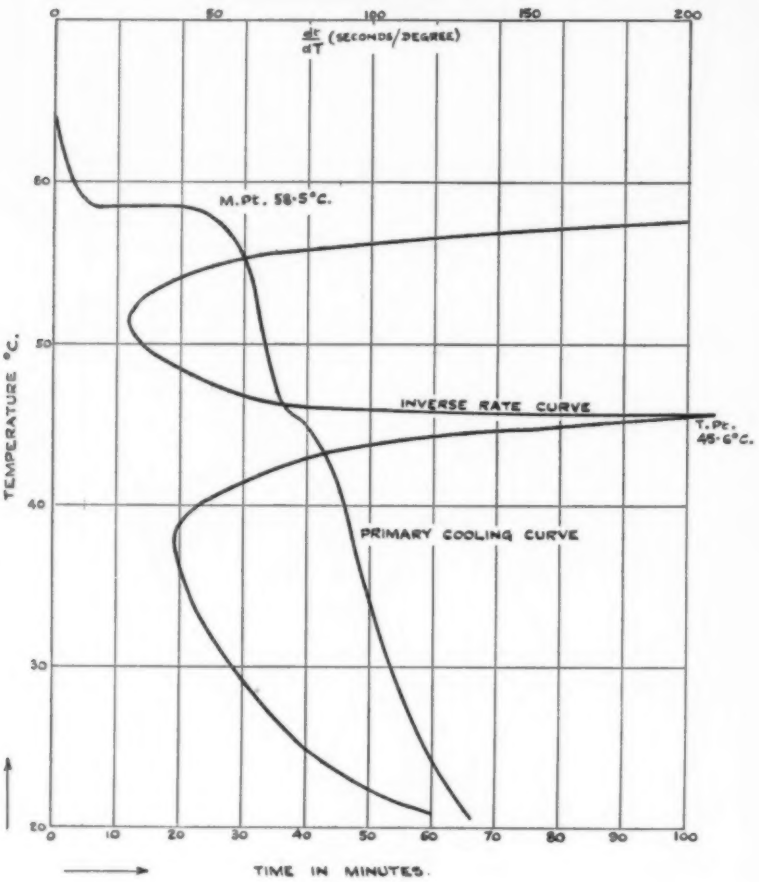

FIG. 5.

COOLING AND INVERSE RATE CURVES FOR 10TH FRACTION FROM VACUUM DISTILLATION OF 135/40 WAX.

will perhaps be as well to stress here that, in a substance like paraffin wax containing a range of constituents of different melting point, transition does not take place at any one particular temperature, but over a range of temperature depending on the number and range in melting point of the constituents present, *i.e.*, the width of cut. The wider cut the wax,

the wider will be the transition range, and the narrower the cut of the wax the smaller the range of transition. The transition point D' therefore only strictly represents the mean of the transition range from α to β form of crystals or, more accurately, the point at which the change from α to β results in the greatest evolution of heat. It will be shown later that with wider-cut products than that considered in Fig. 2 it is at times impossible to obtain a precise transition point even with the inverse-rate method of plotting results.

Effect of Width of Cut on Transition.

Cooling and inverse rate curves for a normal 135/40 grade wax and 5 per cent. middle-cut fractions of similar melting point to the original, obtained therefrom by (*a*) sweating and (*b*) vacuum distillation, are given in Figs. 3–5. The sweated fraction was obtained in a small efficient laboratory electrically controlled stove, whilst the vacuum-fractionated sample was prepared as follows :—

The apparatus consisted of a 1-litre round-bottomed flask fitted with a glass column, length 12·6 in. and internal diameter 0·9 in., connected to a condenser and vacuum receiver. The column was surrounded by a jacket through which air at 350–370° C. was passed. In order to secure good fractionation two iron spirals were fitted inside the glass column; the large spiral had an inner diameter of 0·83 in. and a pitch of 0·53 in., whilst the smaller spiral placed concentrically along the axis of the column had an inner diameter of 0·23 in. and a pitch of 0·36 in. Great care was taken to maintain the whole apparatus vacuum tight, the absolute pressure being kept below 1 mm. of mercury throughout. The charge consisted of 135/40 wax, and the flask was heated in a lead alloy bath; 5 per cent. fractions were collected.

In Figs. 3–5 only that portion of the inverse rate curve which falls below the melting point is drawn. The curves, which are typical of many others obtained, illustrate how the inverse rate method of plotting accentuates the slight kinks or points of inflection in the normal cooling curves, and enables the transition temperature or mean range of transition to be ascertained accurately. They also show clearly how the transition in a normal marketable white wax takes place gradually over a fairly wide range of temperature, due to the relatively wide range of constituents present; this temperature range is somewhat narrower for the sweated fraction, and narrowest of all for the vacuum fractionated wax containing still fewer individual components.

Distillation *v.* Sweating.

Complete cooling and inverse-rate curves were plotted and transition points determined for 5 per cent. fractions 1, 5, 10, 15, 19, and 20 prepared by sweating and vacuum distillation from 135/40 white wax, and the results obtained are given in Table I and Fig. 6, which also includes a curve for normal marketable waxes.

The melting-point figures in Table I illustrate the markedly superior fractionating power of vacuum distillation over sweating.

The curves in Fig. 6 show that the differential between melting point and transition point decreases with increase in melting point in all three cases. For a given melting point it is smallest for a vacuum-fractionated wax and greatest for a normal marketable wax. It follows that the

TABLE I.

Vacuum Distillation v. *Sweating of* 135/40 *White Wax.*

Fraction No.	Distillation.			Sweating.		
	M. pt., ° C.	T. pt., ° C.	Diff., ° C.	M. pt., ° C.	T. pt., ° C.	Diff., ° C.
1	47·1	26·0	21·1	54·0	34·3	19·7
5	54·4	38·8	15·6	56·5	38·6	17·9
10	58·5	45·7	12·8	57·8	41·0	16·8
15	62·6	51·3	11·3	59·4	43·8	15·6
19	66·4	57·8	8·6	62·4	49·8	12·6
20	67·3	60·0	7·3	63·1	50·8	12·3

differential between melting point and transition point decreases with increase in melting point and with narrowness of cut.

WAX BLENDS.

Data deduced from inverse rate curves for blends of 160 and 125/30 white waxes are given in Table II. The data are of special interest as indicating what happens during the cooling of mixtures of two components of very different melting points, each consisting of a relatively large number of individual compounds.

TABLE II.

Blends of 160 (*H.M.P.*) *and* 125/30 (*L.M.P.*) *White Waxes.*

Per cent. 125/30 in Blend.	M. pt., ° C.	Thermal Points.		
		(1).	(2).	(3).
0	71·4	64·2	—	—
2·5	71·1	64·2	—	—
5	70·6	64·2	—	—
10	69·8	63·4	50 *	—
15	69·1	64·1	50·2	—
25	67·4	63 *	52·5	—
40	64·7	—	54·5	29·0
50	63·5	—	55·6	29·5
60	61·0	—	55·8	29·3
75	57·3	—	55·7	30·5
85	54·4	—	—	31·3
95	52·8	—	—	30·5
100	52·7	—	—	30·7

* Not very distinct.

With the addition of the low-melting-point wax there is a gradual reduction in melting point, but after the 50 per cent. mark is reached the relationship is no longer linear. The high-melting-point component shows a distinct transition point at 64·2° C., and although this transition becomes less distinct with increasing proportions of 125/30 wax, it takes place at approximately the same temperature, finally disappearing when the melting

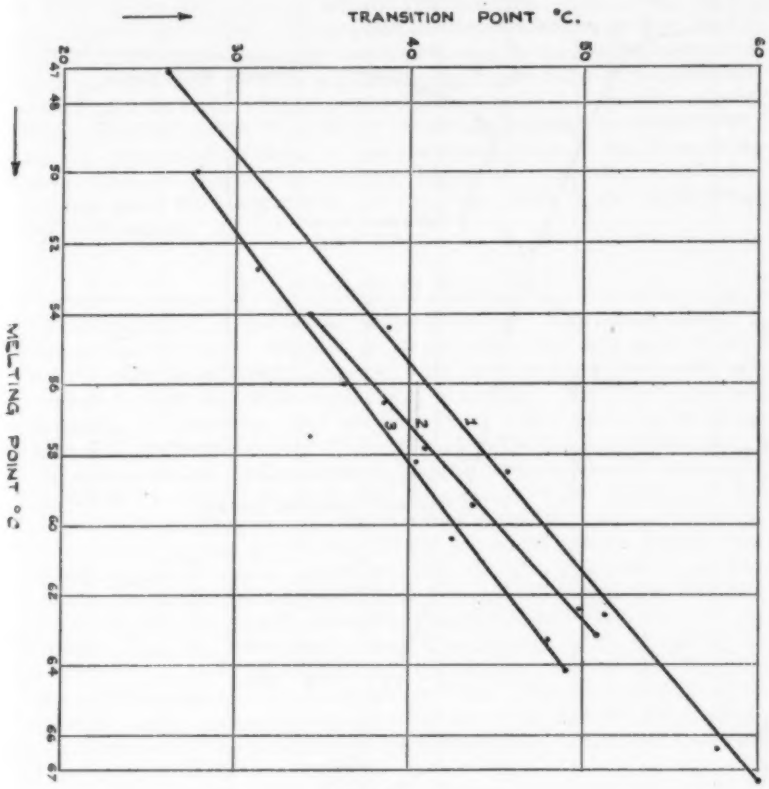

FIG. 6.

RELATIONSHIP BETWEEN MELTING POINTS AND TRANSITION POINTS.

1. Vacuum Fractions From 135/40 White Wax.
2. Sweated Fractions From 135/40 White Wax.
3. Commercial White Waxes.

point of the blend is approximately the same as that of the transition point itself. With blends containing 10–75 per cent. of 125/30 wax there is an evolution of heat, represented by thermal point No. 2, at a mean temperature depending on composition, but always near to the true melting point of the low-melting-point constituent. There can be little doubt, in

fact, that this evolution of heat is due to solidification of the low-melting-point constituent, and not to any transition effect. The 125/30 wax solidifying here will not, of course, be pure; it may have lost some con-

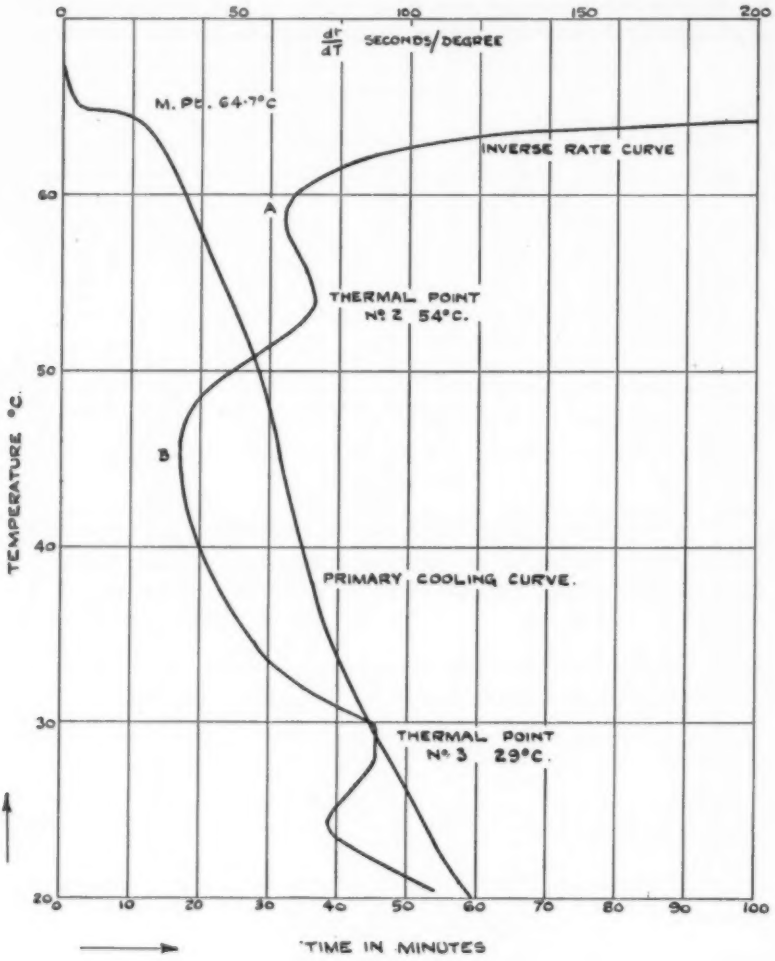

FIG. 7.

COOLING AND INVERSE RATE CURVES FOR 60/40 BLEND OF 160 AND 125/30 WAXES. (REF. TABLE II.)

stituents and gained others to an extent depending on the original composition, thus accounting for the variation in temperature of thermal point No. 2. It is interesting to note that in three of the blends the high-

melting-point component solidifying first, changes from the α to β crystalline form, whilst a portion of the wax is still liquid. For blends containing 40 per cent. or more of low-melting-point wax there is a thermal point No. 3 which gradually increases in intensity, and always takes place approximately at the true transition point of the 125/30 component which it represents.

Cooling and inverse rate curves, typical of the others obtained, are given in Fig. 7 for the 60/40 blend of 160 and 125/30 waxes. The primary cooling curve shows the original melting point distinctly, and two further signs of heat evolution which are accentuated admirably in the inverse rate curve. Since the minimum point *A* is considerably higher than *B*, *i.e.*, the rate of cooling at the higher temperature *A* is lower than at *B*, it appears probable that once solidification starts it carries on continuously to about 50° C., but it is more marked at 54° C., the maximum point on the inverse rate curve, than at temperatures slightly higher or lower than this value. Thermal point No. 3 represents the transition point of the low-melting-point component.

Mottling in Wax.

The appearance of a cake of wax, particularly when pan-moulded, is often spoiled by the presence of mottling, and it has long been realized that the effect is intimately connected with the presence of air in wax and increases to a marked degree with rising oil content. Further, it has been repeatedly demonstrated that mottling never takes place in the total absence of dissolved air even if considerable oil is present in the wax.

If wax is melted and allowed to solidify and cool slowly under the microscope, it can be observed that segregation of air into the crystal boundaries takes place during the transition from the α to the β type of crystal. It is suggested that immediately below the melting point a wax contains appreciable quantities of occluded air, with intrusions of oil and possibly low-melting-point paraffins in the crystal boundaries. At the transition point the crystals change to the β form, and simultaneously air is thrown into the intrusions between the crystals. This produces the mottling effect due to the difference in refractive indices between the wax mass and the intrusions containing air bubbles. The absence of mottling in waxes containing considerable proportions of oil without dissolved air is probably due to the fact that the refractive indices of the wax mass and oil intrusions in this case are similar.

It has been observed that a number of waxes, when quenched in water at about 15° C. from just below the melting point, are at first quite translucent, but after a few hours mottling appears, and gradually increases in intensity with time. This gradual mottling can be readily explained on the above views. These waxes which are quenched from a temperature immediately below the melting point exist at first in the α form. Since the room temperature of approximately 15° C. is well below the transition point, the change to the β form will be restricted. It will, however, take place slowly, accompanied by a very gradual liberation of air and a consequent parallel increase in the mottling effect with time.

It is fully realized that the actual crystal size will affect the degree of

mottling, and it may well be that the action of a dope such as stearin in preventing mottling is to break down the crystalline structure. Alternatively it may reduce the solubility of air in the α modification of the wax.

It has been suggested that the strain in a wax cake due to unequal contraction on cooling produces mottling. If this were the case mottling should take place in the absence of air. It appears more likely that the strain produced in a wax cake, either as a result of unequal contractions in different places or due to the change in coefficient of expansion at the transition point, gives rise to the presence of definite cracks which usually extend to the surface. These cracks should not be confused with the mottling effect.

The author desires to express his thanks to the Directors of The Burmah Oil Co., Ltd., for permission to present this paper for publication.

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ANALYSIS OF OIL–WAX MIXTURES.*

By H. D. Lord, Ph.D.

Synopsis.

The estimation of oil in oil–wax mixtures by the "Press Method" is not very accurate, and, as the A.S.T.M. book states, "The expressible oil and moisture content does not bear a direct relation to the actual oil content of a given sample of paraffin wax."

In the present report it is shown that a more accurate estimation of oil content, and therefore a closer control of refinery pressing and sweating operations, can be obtained by any one of the three methods developed involving measurement of :—

(*a*) Specific gravity at 65° C.
(*b*) Aniline point.
(*c*) Refractive index at 60° C.

The gravity method is perhaps the simplest and most convenient to carry out, and probably represents the best method for routine testing of scales and sweated fractions; it is sufficiently accurate as a control test, giving results to within ± 0·8 per cent. oil.

The refractive-index method is the most accurate of all, giving results to within ± 0·5 per cent. oil, and if an Abbé or other suitable refractometer is available, it can be used conveniently. It is perhaps best suited to research or investigational work where the highest order of accuracy possible is desired.

The methods are, of course, applicable only to scales containing more than, say, 2 per cent. oil as an absolute minimum, and cannot be used for the estimation of oil in finished waxes.

In the large-scale distillation of most crude oils an intermediate fraction preceding residuum is collected, known as H. O. and P. (Heavy Oil and Paraffin), which consists of a mixture of lubricating-oil base (Blue Oil) and crystalline paraffin wax. The paraffin in this fraction is usually removed in two or three stages in special presses, yielding scales of different setting points and still containing appreciable quantities of oil, plus a Blue Oil of relatively low set point, suitable for production of lubricating oils. The scales obtained are then subjected to a sweating operation which, irrespective of equipment used, consists essentially in cooling the molten scale to a solid state and then supplying heat gradually, whereby oil and low-melting-point paraffins are removed selectively, and eventually wax of suitable quality, after earth treatment, is produced. This procedure invariably involves re-cycling and re-sweating of a number of intermediate, or even first residue cuts; and a knowledge of the quality, particularly the oil content, of the primary scales and these intermediate cuts is of great importance if a close check is to be kept on refinery operation.

It is the purpose of this paper to demonstrate how methods have been developed by means of which a very close control of pressing and sweating operations can be maintained.

The paraffin in the H. O. and P. fraction of Burma crude is separated in four stages, and mean characteristics of the first two scales obtained are as follows :—

	M. Pt., ° F.	Tint 1 in. Cell.	Oil Content, % by wt.
First Scale	133·5	12/-	9–10
Second Scale	114	20/-	14

* Paper received 10th February, 1939.

It is possible to obtain an approximate measure of the oil content of these scales and the cuts therefrom by the I.P.T. "Press Method" (P.S. 43). This is a method which has been accepted by the trade for many years, but is admittedly not scientifically accurate. It is of little value as a control test. Accordingly the following methods were developed, depending on the determination of :—

(*a*) Specific gravity.

(*b*) Aniline point.

(*c*) Refractive index.

Experimental.

It was necessary to treat each scale separately, and in the first place the scale was resolved into oil-free wax and oil of 40° F. setting point (equal to that of ordinary Blue Oil), by extraction with ethylene dichloride. Blends of the oil-free wax and the Blue Oil were then prepared, and the gravity, aniline point, and refractive index determined.

Oil Content in Terms of Specific Gravity at 65° C.

Oil-content determination in terms of specific gravity at 65° C. was first suggested and employed by S. T. Minchin as a means of control of the more oily fractions involved in paraffin production. The development and present application of the method are described in this section.

Determination of the specific gravity of an oil–wax mixture in the liquid state by means of a hydrometer is a particularly easy and rapid operation. In the present experiments the mixture was placed in a wide tube 7 in. long and 1½ in. diameter maintained at 65° C. in a thermostat, and the gravity determined; the above temperature was chosen as being high enough to ensure that all samples tested would be in the molten state.

The results obtained are given in Table I.

The values up to 40 per cent. oil are represented graphically in Fig. 1, and the relationship between gravity and oil content over this range is

Table I.

Oil Content in Terms of Specific Gravity at 65° C.

Oil, % by wt.	Specific Gravity at 65° C.	
	First Scale.	Second Scale.
0	0·7800	0·7750
2·5	0·7820	0·7770
5·0	0·7850	0·7800
7·5	0·7875	0·7825
10·0	0·7900	0·7860
15·0	0·7950	0·7910
20·0	0·8000	0·7965
30·0	0·8090	0·8060
40·0	0·8200	0·8180
60·0	0·8430	0·8410
80·0	0·8660	0·8650
100·0	0·8915	0·8915

linear. The accuracy of the method is indicated by the maximum distance of any one point from the straight lines drawn, and it will be seen that it is possible to estimate the oil content of a scale to within $\pm 0{\cdot}8$ per cent.; it is probably the best method of all for routine testing in controlling refinery operations. It can, of course, only be used for scales containing more than, say, 2 per cent. oil, and is not sensitive enough for the estimation of oil in finished waxes.

The method can be applied to oil–wax mixtures other than first and second scales, as the following considerations will show. The slopes of the

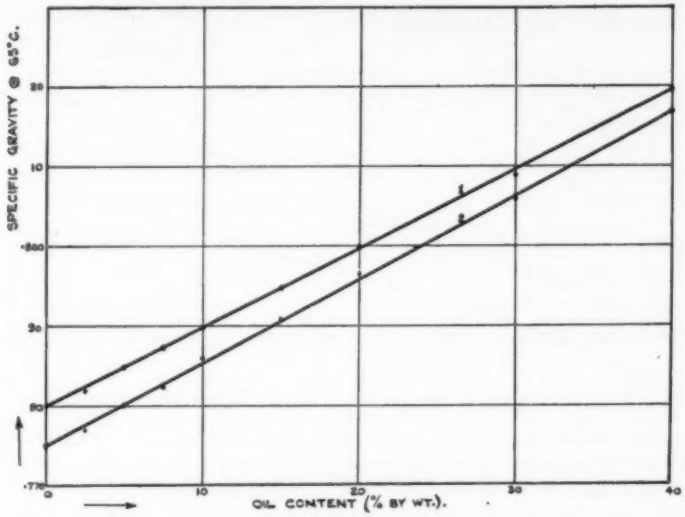


FIG. 1.

OIL CONTENT IN TERMS OF SP. GR. AT 65° C.

1. 1st Scale.
2. 2nd Scale.

lines in Fig. 1 are similar, and the oil content can be determined approximately by equation 1.

$$\text{Oil, \% by wt.} = 976\,(S_x - S_o) \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where S_x = specific gravity at 65° C. of oil–wax mixture
S_o = specific gravity at 65° C. of oil-free wax in mixture.

The value of S_o can be determined from equation (2) if the melting of the wax in the oil–wax mixture is known approximately,

$$S_o = 0{\cdot}775 + (Mo - 120)\,0{\cdot}0003 \quad . \quad . \quad . \quad . \quad (2)$$

where S_o = specific gravity of oil-free wax.
M_o = melting point ° F. of oil-free wax.

The oil content of the mixture can therefore be calculated from its gravity if the melting point of the oil-free wax in the mixture is known approximately.

In order to test the accuracy of equation 1, a number of oil–wax mixtures of known oil content were prepared from commercial grades of Burma waxes and Blue Oil. The gravities were determined and the percentage of added oil calculated according to the equation. The results obtained are given in Table II.

TABLE II.

Agreement between Actual and Estimated Oil Contents from Specific Gravity Data.

Oil–Wax Mixture.	Oil, % by wt.	
	Added.	Calculated.
B.O.C. 125/30 + Blue Oil	10·0 20·0	9·9 20·7
B.O.C. 130/35 + Blue Oil	5·0 10·0	4·6 10·4
B.O.C. 135/40 + Blue Oil	10·0 15·0	10·4 15·2

Agreement between actual and calculated oil content is quite good.

OIL CONTENT FROM ANILINE POINT DETERMINATIONS.

Various investigators have made use of the aniline point, or the critical solution temperature, of mixtures of petroleum products with aniline, in order to estimate the aromatic content, but as far as the author is aware no one has applied this method to the evaluation of oil–wax mixtures. The method appeared quite suitable for the estimation of oil in scales,

TABLE III.

Oil Content in Terms of Aniline Point.

Oil, % by wt.	Aniline Point, ° C.	
	First Scale.	Second Scale.
0	119·4	113·3
2·5	118·3	112·8
5·0	117·8	112·2
7·5	117·2	111·1
10·0	115·8	110·6
15·0	113·9	109·4
20·0	112·8	107·8
30·0	108·9	105·4
40·0	104·4	101·5
60·0	96·1	92·8
80·0	85·6	83·3
100	71·7	71·7

however, and it was accordingly studied at the suggestion of G. R. Nixon, together with the specific gravity and refractive index methods.

A quantity of the oil–wax mixture (approximately 5 gm.) was weighed accurately into a boiling tube and an equal quantity by volume of freshly distilled aniline added. The mixture was heated in a glycerine bath until homogeneous and clear, removed from the bath and stirred vigorously, and the temperature taken when the bulb of the thermometer became invisible. This process was repeated and the mean of the first three readings taken as the "aniline point." The individual readings never varied by more than 0·2° C.

The results obtained are given in Table III, and values up to 40 per cent. oil are represented in Fig. 2.

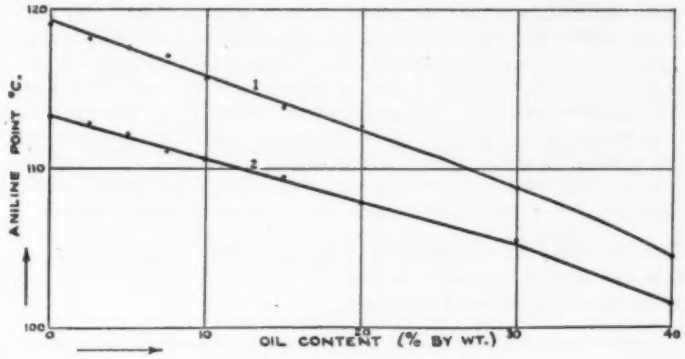


FIG. 2.

OIL CONTENT FROM ANILINE POINT.

1. 1st Scale.
2. 2nd Scale.

Over the range 0–30 per cent. oil the relationship between aniline point and oil content for both scales is linear and the lines are of similar slope. From the mean slope of these lines equation (3) has been deduced.

$$\text{Oil content (\% by wt.)} = 2{\cdot}97\,(A_o - A_x) \quad . \quad . \quad . \quad (3)$$

where A_o = aniline point ° C. of oil-free wax.

A_x = aniline point ° C. of oil–wax mixture.

It applies, of course, only for mixtures containing up to 30 per cent. oil.

In order to test the accuracy of equation 1 a number of oil–wax mixtures of known oil content were prepared from commercial grade Burma waxes and Blue Oil. The aniline points were determined and the percentage of added oil was calculated according to the equation. The results obtained are given in Table IV.

Agreement is quite good, and the method could probably be applied with success to routine testing. It requires only a very small quantity of scale, but this is not usually of importance, and as it possesses no other advantages above the gravity method previously described, the earlier method is presumably to be preferred in all cases.

The variation in aniline point with melting point of a wax is illustrated in Fig. 3. The relationship is linear and can be expressed by the following equation :

$$\text{Aniline Point } ^\circ\text{C.} = 0{\cdot}319 \times \text{Melting Point } ^\circ\text{F.} + 75{\cdot}6 \quad . \quad . \quad (4)$$

TABLE IV.

Agreement between Actual and Estimated Oil Contents from Aniline Point Data.

Oil–Wax Mixture.	Oil, % by wt.	
	Added.	Estimated.
B.O.C. M. pt. 127·8° F. + Blue Oil	5·0	5·4
	15·0	14·7
B.O.C. M. pt. 133·4° F. + Blue Oil	10·0	10·6
	20·0	21·3
B.O.C. M. pt. 138·4° F. + Blue Oil	10·0	9·6
	15·0	14·6

The two different temperature scales have been retained, since aniline points are usually expressed in degrees Centigrade and melting points of paraffin waxes in degrees Fahrenheit.

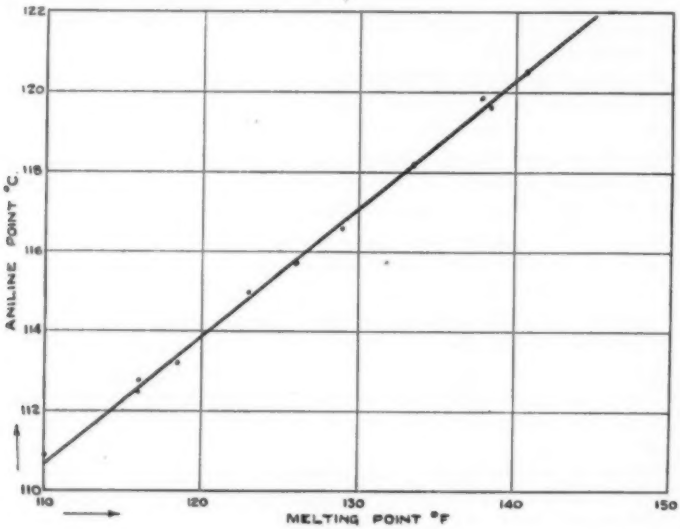


FIG. 3.

VARIATION IN ANILINE POINT WITH MELTING POINT OF PARAFFIN WAX.

Oil Content in Terms of Refractive Index at 60° C.

Various investigators have suggested methods for the determination of oil in scales from refractive index data. Wilson and Wilkin [1] used ethylene dichloride to separate the oil from the wax, and estimated the oil in the filtrate after distilling off the ethylene dichloride and adding a known weight of oil of known refractive index. The method is rather laborious. Diggs and Buchler [2] used a direct refractometer method, but prepared so-called oils from waxes by filtration through clay. Piotrowski and Winkler [3] used a similar method, and assumed that after filtration of 10 gm. of scale through 5 gm. of Terrana earth at 80° C., the first few drops of the filtrate were oil-free. It will be shown later that the waxes in both cases probably contained oil.

In view of the above considerations, it seemed worth while to investigate the method further. Accordingly the refractive indices of the oil–wax mixtures described earlier in this paper were determined at 60° C. using an Abbé refractometer. It was possible to read this instrument to the fourth decimal place and to maintain the temperature constant to within 0·2° C. A temperature of 60° C. was chosen as being high enough to maintain any scale in the liquid state. In the case of finished waxes of melting point higher than 60° C. the refractive index was measured at 62° C. and the result corrected to 60° C. using a coefficient of 0·0004/° C. This coefficient was obtained for a number of waxes and for the Blue Oil used.

The results obtained are given in Table V.

Table V.

Oil Content in Terms of Refractive Index at 60° C.

Oil, % by wt.	Refractive Index at 60° C.	
	First Scale.	Second Scale.
0	1·4370	1·4348
2·5	1·4383	1·4359
5·0	1·4394	1·4373
7·5	1·4410	1·4388
10·0	1·4425	1·4404
15·0	1·4455	1·4434
20·0	1·4485	1·4463
30·0	1·4547	1·4529
40·0	1·4608	1·4594
60·0	1·4740	1·4727
80·0	1·4880	1·4870
100	1·5029	1·5029

The values up to 40 per cent. oil are represented in Fig. 4, and it will be seen that it is possible to estimate the oil in either scale to within $\pm 0{\cdot}5$ per cent. by this method.

The curves in Fig. 4 do not depart far from a linear relationship, and the slope decreases slightly with increase in melting point. The variation in refractive index with the melting point of the wax constituent is very small compared with that due to the oil present, and this is an important practical

result, since it implies that the method can be used with success for the evaluation of oil–wax mixtures and will not depend greatly on the melting point or width of cut of the wax in the mixture.

For mixtures containing from 5 to 40 per cent. oil the following equation can be deduced from the curves in Fig. 4.

$$\text{Oil content (\% by wt.)} = 1635\ \{\mu_x - (\mu_o - 0{\cdot}0007)\} \quad . \quad (5)$$

where μ_o = refractive index at 60° C. of oil-free wax.

μ_x = refractive index at 60° C. of oil–wax mixture.

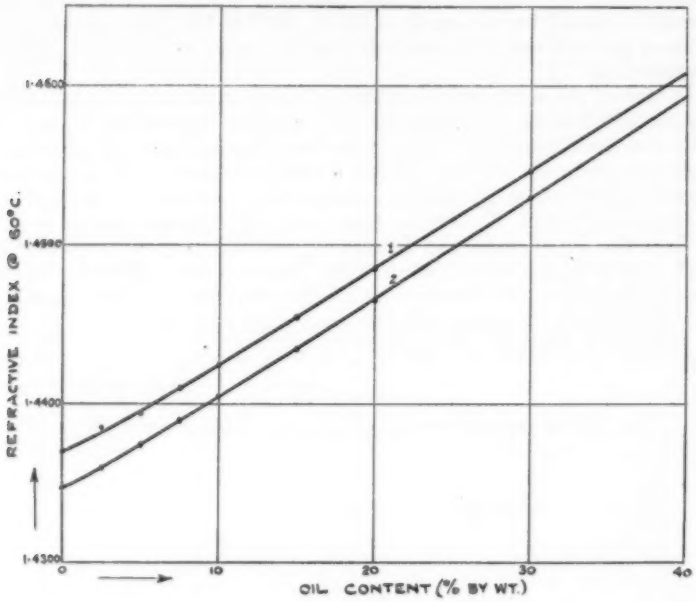


FIG. 4.

OIL CONTENT FROM REFRACTIVE INDEX.

1. 1st Scale.
2. 2nd Scale.

In order to test the accuracy of this expression, a number of oil–wax mixtures were prepared from commercial Burma waxes, the refractive index was determined at 60° C., and the percentage oil in the mixture calculated according to equation 5. The results obtained are given in Table VI.

Agreement between calculated and actual percentage of oil is very satisfactory. This is again more significant when it is remembered that the equation was deduced from figures for specially prepared waxes, whilst the values in Table VI apply to mixtures containing commercial waxes which have not received special treatment and are of different width of cut.

It is necessary in applying this method to know the refractive index of

the oil-free wax in the mixture, and, if a very accurate value is desired, the wax can be separated by solvent extraction with ethylene dichloride, butanone, or alcohol–ether mixture. From a practical standpoint, however, it is desired to emphasize again that the refractive index of a wax varies only slightly with melting point, and therefore a sufficiently accurate evaluation of an oil–wax mixture can be obtained if the melting point of the wax in the scale is known approximately.

In normal refinery operations the wax present in any given scale does not vary much from time to time, and it is only necessary to separate this

TABLE VI.

Agreement between Actual and Estimated Oil Contents from Refractive Index Data.

Oil–Wax Mixture.	Oil, % by wt.	
	Added.	Estimated.
B.O.C. M. pt. 113·9° F. + Blue Oil	10·0 20·0	10·2 20·4
B.O.C. M. pt. 127·8° F. + Blue Oil	10·0 15·0	10·2 14·9
B.O.C. M. pt. 133·4° F. + Blue Oil	10·0 20·0	9·5 19·5
B.O.C. M. pt. 138·5° F. + Blue Oil	5·0 15·0	5·3 15·6

constituent for test at periodic intervals by, say, solvent extraction. Alternatively, it can be separated by laboratory pressing or filtration through earth, its melting point taken, and the refractive index read off from Fig. 5. Since the lowering in melting point of a wax due to oil is only approximately 1° F. for 5 per cent. oil, it follows that the small quantity of oil left in the wax by this procedure does not affect the result materially.

In connection with filtration through earth or clay, which is the method used by Diggs and Buchler [2] to obtain oil-free waxes, it should be pointed out that this procedure almost certainly leaves appreciable quantities of oil in the wax. In order to test this, two oil–wax mixtures containing respectively 15 per cent. and 20 per cent. oil were filtered through fuller's earth at 100° C. The first three drops of wax to filter were collected separately in each case, and this represented a treatment of 500 lb./gall. of earth. Although the waxes were colourless they contained according to equation 5 approximately 4 per cent. oil in each case. Furthermore, the next fractions to filter, representing a treatment of 60–70 lb./gall., had the same refractive index as the first three drops corresponding to the same oil content. It therefore appears that this is the limit of oil removal by this method, and it is likely that filtration through other absorbent media will have a similar effect. Diggs and Buchler assumed that because the

refractive index of a wax attained a constant value on repeated filtration through clay it was oil-free. It appears more probable that, as in the cases cited above, the limit of oil removal had been reached and the wax still contained oil.

In conclusion, it is considered that the method of evaluation of oil–wax mixtures suggested in this section is preferable to any other for the estima-

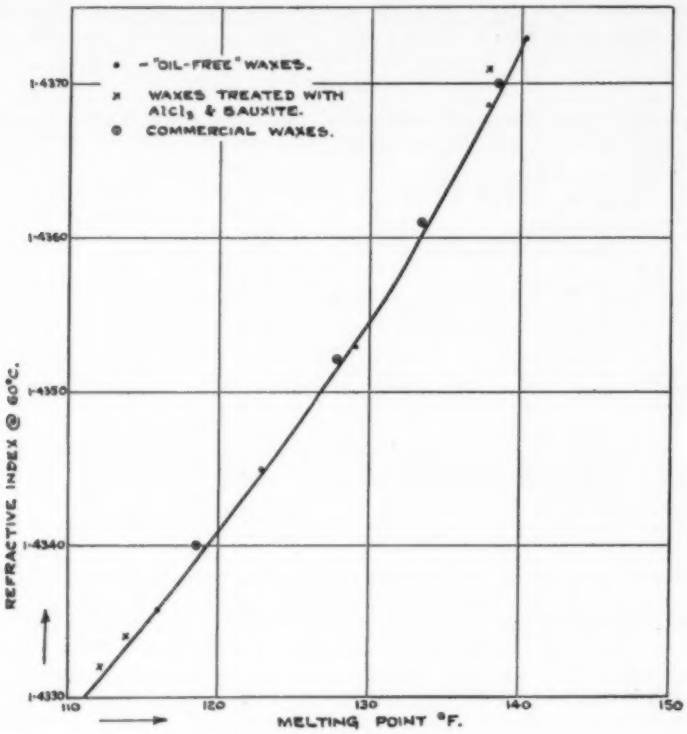


FIG. 5.

VARIATION IN REFRACTIVE INDEX AT 60° C. WITH MELTING POINT OF PARAFFIN WAX.

tion of the oil content of scales in research or investigational work. The method is easy and rapid, and gives results to within $\pm 0{\cdot}5$ per cent. oil. Further, only two to three drops of the liquid mixture are required. In view of this fact it is extremely important, however, to pay particular attention to sampling. The mixture should be melted and well stirred before removing two or three drops for test. The method is not sensitive enough to be applied to finished waxes.

General Conclusions.

It is suggested that all three methods of estimation of oil in scales given in this report are more convenient, satisfactory, and accurate than the Press Method ref. I.P.T. Serial Designation P.S. 43 and A.S.T.M. D.308–29 T. This latter method, in fact, as the A.S.T.M. book suggests, gives results for expressible oil and moisture which do not bear a direct relation to the actual oil content of a given sample of paraffin wax.

The gravity method is probably the simplest and most convenient of all to carry out, and from that point of view it is the most suitable for routine testing of refinery scales and sweated fractions. It certainly does keep a good check on processing of H. O. and P. and normal sweating operations, and is sufficiently accurate for the purpose. If an Abbé or other suitable refractometer is available the Refractive Index method can be used conveniently, and is the most accurate of all. It is perhaps best suited to research and general investigational work where the highest order of accuracy possible is desired.

The methods are, of course, applicable only to scales containing more than, say, 2 per cent. oil as an absolute minimum, and cannot be used for estimation of oil in finished waxes.

The thanks of the author are due to the Burmah Oil Co., Ltd., for permission for the publication of this paper.

References.

[1] R. E. Wilson and R. E. Wilkin, *J. Instn chem. Eng.*, 1924, **16**, 9–12.
[2] Diggs and Buchler, *ibid.*, 1927, **19**, 125–127.
[3] Piotrowski and Winkler, *Erdöl und Teer*, 1930, **6**, 463–465; *J. Instn Petrol. Tech.*, 1930, 448A.

ROUMANIAN BRANCH.

TWELFTH ANNUAL DINNER.

THE Twelfth Annual Dinner of the Roumanian Branch of the Institute of Petroleum was held at the Colonade Restaurant, Bucharest, on the 14th January, 1939. The Chairman, Mr. I. S. Rutherford, occupied the Chair and eighty-five members and visitors were present. After the toast of H.M. the King of Roumania, proposed by the Chairman, MR. D. I. MAXWELL proposed the toast of "The Petroleum Industry of Roumania."

MR. MAXWELL said :

THE PETROLEUM INDUSTRY OF ROUMANIA.

In proposing this toast, it has been the custom to review briefly the progress made in the industry during the past year and to estimate the probable trends in the various branches. Beginning with the source of the raw material, I shall refer to each branch in its order of sequence.

Upon examining the production rate of crude oil, we find that in 1938 a total of 6,600,000 tons were produced, compared with 7,153,000 in 1937, which represents a drop of 550,000 tons, or 8 per cent. This decrease in production added to that of 1937 below 1936 shows a reduction of 2,104,000 tons, or 24·2 per cent. for the past two years.

With the drop in production there has been a decrease in drilling activity. The total meters drilled in 1938 amounted to 293,000, compared with 389,000 in 1937, a decrease of 24 per cent. Although a number of factors were responsible for the decreased drilling, the two principal ones were the cessation of work in the Bucşani field and the formation of unit agreements reducing competitive drilling. During 1937 there was much competitive drilling in the Bucşani, Moreni, Piscuri, and Boldeşti fields. Thus, excluding the Bucşani field from the comparison, we obtain a net reduction of 14 per cent. in drilling activity and an 8 per cent. drop in crude production for 1938 under 1937.

The seriousness of the situation is evident to all, because no major discoveries were made during the year, and it means that reserves are being drilled up. This condition will, in a few years, unless new discoveries are made, further decrease Roumania's influence in the world petroleum market. Their present share, 2·43 per cent., small though it may be, is of vital importance to Roumania, because the industry in 1937 exported products in an amount equivalent in value to 40·6 per cent. of the total exports, and contributed in taxes, royalties, etc., seven thousand million lei to the State, equal to 29 per cent. of the National Budget.

Of the various fields there are only two major increases in production—namely, Baicoi-Tintea with 360,000 tons and Ceptura with 335,000 tons. The greatest decreases among the major fields occurred in Bucşani, Boldeşti, and Moreni. Ceptura, which showed an increase over the previous year, is expected to show a decrease in 1939. Baicoi-Tintea, however, will continue to expand. Although the overall decrease in Roumanian production was only 8 per cent., this decrease would have been considerably greater without the increases in the Ceptura and Baicoi-Tintea fields.

Of the some thirty-five Roumanian fields or areas, the most important remain, with the exception of Bucşani, the same as those of last year. Those which during 1938 made over 535,000 tons are West Gura Ocniţei, Moreni, Baicoi-Tintea, Boldeşti, and Ceptura. Ceptura began to come into prominence during 1937 due to drilling on the North flank, but at present the most favourable areas have been drilled up, and the field will consequently begin to decline. At Tintea the Meotic development is still extending the productive area, and the field will assume an even more important position during 1939.

With the exception of Tintea, extensions in other fields contributed a negligible amount to the country's production.

As mentioned before, no major discoveries were made during 1938. The most important, however, would appear to be the well now testing at Magurele, but it does not seem likely that a major field will result. The results of the 1938 exploratory drilling are rather disappointing, since a total of ten wildcats were drilled in areas of known structure.

In viewing the region within which development has concentrated during the past year, we can see little prospect of opening new fields of importance or, with the exception of Baicoi-Tintea, greatly extending the present ones. We believe that it is the consensus of opinion that other regions of Roumania will have to be explored in order to find additional large fields.

Before the long and expensive search for this oil may be commenced, it is necessary that there be State land grants under conditions where the profit possibilities will justify the risks involved. Towards this end the mining laws are being revised, and are expected to come into force during the early part of 1939. At the request of the State, the oil companies submitted their recommendations for revision of the present mining laws, and a commendable spirit of co-operation among the companies, and between the companies and the State, has been shown.

When the new mining laws come into effect, we predict that Roumania will experience a new area of development; but this, of course, will have to be accompanied by a great amount of geophysical work and exploratory drilling and, consequently, will represent an enormous investment on the part of the companies.

During the year several very notable steps towards co-operation between the companies were carried out through conservation agreements and the formation of unit areas of pooling. Among these we might mention Ceptura North flank and Tintea pro-rating agreements, and the exploration agreement in the Malaeşti area; but the most important is the Tintea-Liliești pooling agreement, since it paves the way for further unit areas of this type and will do much towards eliminating wasteful competitive operations and result in greatly conserving the country's resources.

Natural Gas.

In the natural-gas division of the industry there has been but little progress made in the past year for the utilization of this natural resource. The production of natural gasoline amounted to 306,446 tons in 1937 and approximately 275,000 in 1938. As the estimated total capacity of the gasoline recovery plants amounts to 650,000 tons per year, we observe that

the plants were being operated at 42·5 per cent. rating. Gas blown to the air is estimated at 513,000,000 cu.m. equivalent to 500,000 tons of fuel. This waste is being permitted to continue in spite of the fact that wood and other fuels for domestic heating are increasing in price. Several gas-line projects have been proposed, but nothing tangible has yet been developed.

Crude Oil.

From a manufacturing standpoint the crude oil produced in Roumania is of exceptional quality, in that it averages about 0·850 density and is low in sulphur. The crude-oil quality may be roughly divided into two grades, non-paraffinous and paraffinous. The non-paraffinous, approximately 15 per cent. of the total production, is the source of the high-octane naphtha, tractor fuels, low pour-point gas and fuel oils, lubricating oils, asphalt and naphthenic acids. Primarily because of its low pour characteristics and the low quantities produced, this type of crude demands a price approximately 10 per cent. higher than paraffinous. The Roumanian non-paraffinous crude presents no unusual refining difficulties.

For the paraffinous crude, however, adequate heated storage must be provided to handle the high pour stocks, and in the past two years the increasing salt content has presented problems in salt removal, corrosion, and sediment in the residue. The products obtained from this type of crude with the usual refinery equipment cannot compete in the open market because of inferior quality, with special emphasis on octane and pour. The quality can be improved only by the installation of expensive refining processes, such as viscosity breaking, reforming, and solvent treating units.

Refining Industry.

The crude refining capacity of Roumania is estimated at 11,657,000 tons per year, which is 176 per cent. more than the present production. Installed cracking capacity amounts to 1,800,000 tons per year, which is approximately 67 per cent. of the capacity required to obtain the most economical gasoline to fuel oil ratio.

For the production of high octane naphthas, 70 plus, there is less than 1000 tons capacity per day available. Eventually, in order to meet the demand for 70/72 clear octane naphthas, the refineries will be compelled to instal one of the modern thermal or catalytic cracking units. In the meantime the European consumers should be educated to the use of leaded gasolines; if this can be done successfully large expenditures on cracking equipment can be postponed.

At the present time no high viscosity index lubricating oils are produced from 100 per cent. Roumanian crude. Oils with a good viscosity index are to be found on the market, but they are either imported, or blends of imported with Roumanian oils. The factors responsible for this situation are: low consumption of motor oils, lack of good lubricating oil crudes, and no solvent treating units. It is true that good motor oils can be manufactured from Roumanian crude, but the enormous investment required cannot be justified economically.

As many of you doubtless know, the manufacturing end of the Petroleum Industry is rapidly developing into a chemical industry. The former simple distillation and cracking operations are fast becoming the initial

steps in chemical processes that utilize the accumulated knowledge of physics and chemistry in their operation. The research worker has been able by means of catalysis, synthesis, and solvent extraction to develop processes that are commercially applicable. Among the more recent developments are catalytic cracking, thermal and catalytic polymerization of gases, polymerization of unsaturates with sulphuric acid, known commercially as the hot and cold acid contact processes, and alkylation. These processes produce superior motor fuels.

In the field of synthetic organic chemistry, beginning with the raw materials of petroleum, a great number of products are being manufactured, such as alcohols, glycols, glycerol, ketones, esters, fatty acids, plastics, and rubber. These developments are of far-reaching consequence to the consumer, in that a new source of supply has been made available.

Marketing.

A review of the marketing situation shows that domestic consumption increased from 22·2 per cent. to 27·4 per cent. of the total products available. Prices were lower on all products with the exception of asphalt and fuel oil. As the fuel oil, however, represented 68·46 per cent. of the domestic consumption, the weighted average price of all products shows a slight increase for 1938 over 1937.

Total exports dropped to a new low level of 72·6 per cent. Export prices for the first nine months of 1938 compared with the same period in 1937 show a weighted average decrease of 11·5 per cent. In addition to the reduced prices for products, the railway increased transportation costs 18·2 per cent. from 1st March. Later in the year—September—transport costs on fuel oil were reduced 20 per cent., which amounted to a weighted average reduction of 4 per cent. on all products.

The exceedingly high transport costs in Roumania, compared with the United States, often reduces the margin of profit to the point where the refiner cannot compete with products from the Gulf in the Western European market. This situation is offset somewhat by the higher Constanța price quotations above Gulf, and the clearing arrangements.

During the past year a number of changes were made in the regulations of the National Bank of Roumania governing the control of foreign currency, which were of decided benefit to the petroleum companies. The National Bank of Roumania revised practically all of the clearing agreements with the principal countries to which petroleum products are exported, with the result that collections for sales have been greatly facilitated and losses due to the re-valuation of various currencies have been practically eliminated.

New clearing agreements governing petroleum products were closed with several countries during the last year which opened new markets for the industry.

On 1st April, 1938, the National Bank arranged to place at the disposal of the petroleum companies for their own use a certain percentage of free exchange realized from exports to those countries in free exchange. This arrangment has proved to be of great benefit to the industry, as it has made it possible for the companies to purchase materials they require for exploitation and exploration that must be obtained from abroad in free currency, and to meet their financial obligations abroad.

The Minister of National Economy and the Directors of the National Bank of Roumania are fully cognisant of the difficulties with which the industry is now faced, and are doing everything in their power to improve the situation.

Although the results obtained in 1938 were less than the year before, conditions might have been worse, in that the outlook for this year is not too encouraging. It is believed, however, that the Government will enact legislation encouraging further development by the industry, and so it is with a spirit of faith and hope that I propose the toast of "THE ROUMANIAN PETROLEUM INDUSTRY."

The toast of "The Institute of Petroleum" was proposed by MR. PERCY R. CLARK, Past-Chairman of the Branch.

MR. CLARK said that since they had last met, the old Institution of Petroleum Technologists had become the Institute of Petroleum, and he was the first person in Roumania to have the privilege of proposing a toast to the Institute in its new form and under its new title. Some people had asked why the Institution should have been re-named. Without being facetious he would reply that the Institution was re-named because it concurrently became something else; and the Institution in making itself something else had also been conforming to the trend of modern industrial thought. The old Institution had catered mainly for the field and refinery technical staffs—in other words, for a part only of the industrial side of the petroleum world. They had to appreciate the marked change which had been coming over world economic conditions during the last few decades, owing to the excessive development of production in comparison with the development of distribution. But this problem, however, was no longer one of production, but of rational distribution. It was to the financial, and particularly the distribution, side of their business that they had to devote their closest attention to-day.

It was in conformity with this trend that the Council of the former Institution of Petroleum Technologists had been prompted to bring about a change in its constitution, so that in the new Institute's ranks can be included specialists from every branch of activity necessary to bring the petroleum industry to success. Experience told them that it was just as difficult to obtain a first-rate financial manager, chief clerk, chief accountant, or comptroller, whichever terminology they agreed to use, as it was to get a good engineer. Anyone at the head of a large industrial organization with a commercial end to it would know that the most difficult man of all to find was the competent sales manager.

The new Institute of Petroleum was a recognition of these basic principles, and henceforth it would not only be production and refinery men who would play a rôle in the affairs of the Institute, but also representatives of the financial and distribution ends.

It was therefore a great pleasure to him to offer the Council of the Institute of Petroleum their congratulations and the best wishes on this new era in the Institute's history. He hoped that 1939 would be a year of intensive and extensive development of their Institute.

In concluding his toast, Mr. Clark read a congratulatory telegram which would be sent immediately to the parent Institute.

THE INSTITUTE OF PETROLEUM.

TWENTY-FIFTH ANNUAL REPORT.

1938.

THE Twenty-Fifth Annual Report of the Council covering the activities of the Institute during 1938 is presented for the information of the members.

MEMBERSHIP.

The changes in membership which occurred during 1938, and the total membership of all classes on 31st December, 1938, are summarized in the Table below :—

	Total Dec. 31, 1937.	CHANGES DURING 1937.							Total Dec. 31, 1938.
		New.	Transferred to.	Resigned.	Deceased.	Removed.	Transferred from.	+ or −.	
Hon. Mems. .	21	—	—	—	1	—	—	− 1	20
Members .	713	46	8	9	7	15	—	+23	736
Assoc. Mems.	527	41	7	13	2	22	7	+ 4	531
Students .	82	28	—	4	—	3	7	+14	96
Associates .	98	5	—	3	—	4	1	− 3	95
Totals .	1441	120	15	29	10	44	15	+37	1478

The new classes of membership (Fellow, Member, Associate Member and Student) were not operative during 1938.

The Council has to record with deep regret the decease of the following members during 1938 :—

	Date elected.	Class of membership.
ASHWORTH, A. A.	1924	M.
CHADWICK, A.	1931	M.
CHITTENDEN, A. L.	1922	M.
HOLDE, D.	1933	Hon. M.
HOWLETT, W. S.	1937	M.
KENNEDY, E. D.	1937	A.M.
MILES, J. A.	1920	M.
MITCHELL, J. P.	1933	M.
MUIR, J. M.	1920	M.
RICHMOND, A. F.	1931	A.M.

Prof. D. Holde, who died in Berlin in June 1938, was elected a Life Honorary Member of the Institute in 1933, in recognition of his distinguished contributions to the chemistry of petroleum.

HONOURS.

Mr. F. C. Starling (Hon. Mem.) received the honour of Commander of the Order of the British Empire, in the New Year Honours List, 1939.

Representation on Other Bodies.

The Institute has been officially represented on the following bodies :—

The American Society for Testing Materials : Lt.-Col. S. J. M. Auld, Dr. A. E. Dunstan, Dr. F. H. Garner and Mr. J. Kewley (Honorary Members of Committee D-2 on Petroleum Products and Lubricants).
The British National Committee of the World Power Conference : Dr. A. E. Dunstan.
The Technical Committee of the Chemical Engineering Conference : Lt.-Col. S. J. M. Auld.
The British Standards Institution Petroleum Industry Committee : Lt.-Col. S. J. M. Auld, Prof. J. S. S. Brame, Dr. A. E. Dunstan, Mr. B. J. Ellis, Dr. F. H. Garner, Mr. J. Kewley and the Secretary.
The Permanent Council of World Petroleum Congresses : Lt.-Col. S. J. M. Auld, Mr. T. Dewhurst and the Secretary.
The International Standards Association Conference in Berlin, June 1938 : Dr. F. H. Garner.
XVIIIth International Geological Congress (London, 1940) : The President and Mr. T. Dewhurst.
Rubber Technology Conference (London, 1938) : Dr. F. B. Thole and Mr. W. E. Gooday.
Diesel Engine Users Association : Mr. L. J. Le Mesurier and Mr. N. Mitchell.
Ramsay Memorial Laboratory : Mr. J. Kewley.
Permanent International Association of Road Congresses : Dr. P. Spielman.
Benjamin Franklin Memorial Dedication, Philadelphia : Mr. W. D. Brown.
Parliamentary Science Committee : Lt.-Col. S. J. M. Auld, Mr. T. Dewhurst and Dr. E. R. Redgrove.
Imperial Institute, Advisory Council on Mineral Resources : Dr. A. E. Dunstan.

The Institute has also been represented on numerous Sub-Committees of the British Standards Institution.

Benevolent Fund.

The audited statement of Receipts and Payments of the Benevolent Fund during 1938 is submitted below. The Receipts of the Fund from all sources were £106 18*s.* 4*d.*, as compared with £136 14*s.* 2*d.* in 1937. (The 1937 contributions included the special donations received in response to the Council's Coronation Appeal.)

Contributions to the Fund during 1938 were received from :—

Adams, A. C.
Andrews, B. G.
Auld, S. J. M.
Beavan, A. M. E.
Blakiston, J. H.
Bolton, R. P.
Bressy, R. J.
Brodie, N. M.
Bush, L. A.
Cameron, I.
Carter, Ashley.
Charlton, A. E.
Clement, L.
Clifford, G.
Cohn, T.
Cole, F. A. J.
Crichton, R.
Dalley, C.
Dewar, K. G.
Downs, W. W.
Dunkley, G. W.
Dunstan, A. E.
Edeleanu, I.
Egloff, G.
Ellis, B. J.
Evans, R. J.
Fay, E.
Ferguson, B. C.
Fletcher, H. D.
Frewing, J. J.
Garner, F. H.
Gould, G. C.
Griffiths, P. M.
Hamilton, A.
Henson, F. R. S.
Higgs, P. G.
Hills, S. R.
Jackson, J. S.
Jameson, J. A.
Jennings, J. C.
Kelly, M. E.
Kewley, J.
Lavington, H. V.
Le Mesurier, L. J.
Lorne, H. T.
Mackilligan, R. S.
Masters, J. S.
McCreath, T. T.
Middleton, F.
Mitchell, J. P.
Moon, C. A.
Nash, A. W.
Owen, A. G.
Parr, R. W.
Parrish, J.
Perks, A. J.
Porter, P. N. D.
Purdie, A. C.
Purves, A. R.
Redgrove, E. R.
Reid, H. W.
Reynard, H. C.
Richard, A. H.
Richards, G. A.
Ruthven-Murray, A. J.
Samuel, D. L.
Sanders, J. McConnell.
Schlumberger, M.
Scott, G. H.
Smallwood, W.
Southwell, C. A. P.
Spielman, P. E.
Taitt, G. S.
Taylor, T. M.
Tullett, G. V.
Tweed, R. R.
Walsh, D. M.
Walter, G.
Wood, C. W.
Young, J. H. M.
Trinidad Branch.
Shell Marketing Company, Central Laboratories.
Oil Industries Club.

The Council wishes to thank all members who have contributed to the Fund, and in particular those members of the Trinidad Branch, whose contributions have formed a substantial proportion of the total during the past five years.

Finance.

The Audited Revenue Account for 1938 and the Balance Sheet as at 31st December, 1938, are given below. The deficit balance of £813 13*s.* 8*d.* is more than accounted for by expenditure on the new Adelphi premises, covering legal charges for the lease, electric and other fittings, removal expenses and new furniture. The whole of this expenditure has been charged to current revenue. The value of office furniture and library books has been written down to the round figure of £200.

Before charging the expenditure on the Adelphi, there was a surplus of £92 18*s.* 2*d.* Whilst this is considerably less than the corresponding surplus of 1937 (£720), a comparison of various items for the two years will indicate that the increased expenditure was mainly of a non-recurrent nature, notably in the case of Publications and Meetings. This was mainly due to the expenses of the Scottish Conference, followed by the publication in December 1938 of its transactions. A further item of extraordinary expenditure was that of legal expenses in connection with the change of name and constitution. The income from members' subscriptions and publications, on the other hand, show satisfactory increases.

The difference between cost and market value of investments is the normal consequence of market conditions at the end of the year. The regular valuation of securities was made during the year, and on the advice of financial advisers it was decided to make no change in the investments held.

Changes in Constitution.

Important changes in the Memorandum of Association and Articles were approved by the members at a Special General Meeting on 22nd March, 1938. These modifications had been under discussion by the Council for a considerable time. They were designed to bring the constitution of the Institute into line with the trend of developments in its activities, to provide greater freedom for growth, and to broaden the basis of its membership. A corollary to these modifications was the change of name from the "Institution of Petroleum Technologists" to "The Institute of Petroleum."

The Special Resolution relating to the change of name was submitted to the Board of Trade, and the certificate of the Registrar of Companies approving the name "The Institute of Petroleum" is dated April 14th, 1938.

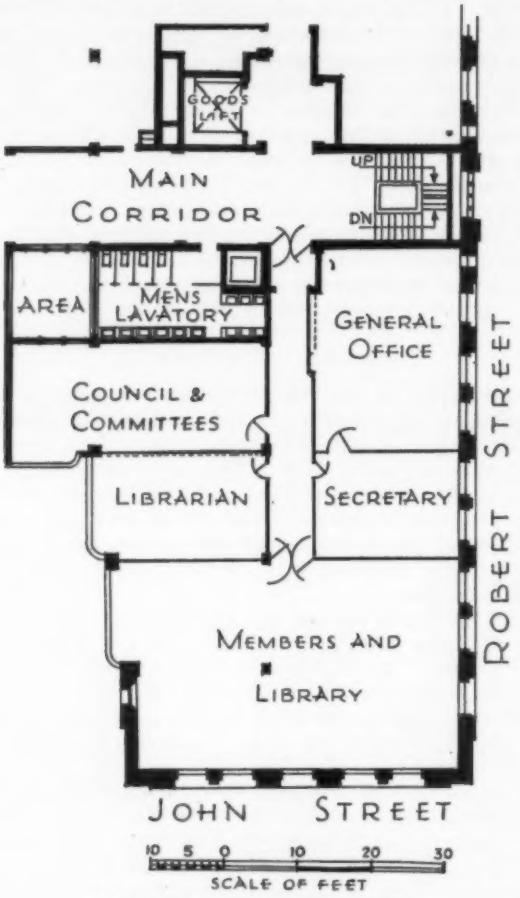
The Special Resolutions incorporating the changes in the Memorandum of Association and Articles were the subject of a Petition to the High Court of Justice. The approval of the Court was given by Mr. Justice Crossman on 30th May, 1938.

At the Annual General Meeting, which followed the Special General Meeting on 22nd March, alterations in the By-Laws were approved by the members. The principal change was that relating to the classes of membership. In lieu of Members, Associate Members, Associates, and Students, the new categories of membership are Fellows, Members, Associate Members, and Students. The definition of each category differs from the definitions of the former categories, in such a manner as will enable the new Institute to include in its membership persons engaged in all branches of the petroleum and allied industries.

For administrative reasons it was not considered advisable to make the new categories of membership operative before the end of 1938. They came into force in January 1939, when the Council's proposals for the re-classification of membership were approved at a Special General Meeting on 10th January, 1939.

Premises.

The lease of the Aldine House offices, which had been occupied since June 1923, expired in June 1937, and was thereafter renewed on an annual



PLAN OF OFFICES AT THE ADELPHI

basis. Whilst appreciating the advantages of the Institute possessing "a house of its own," the Council came to the conclusion that its limited capital resources and annual income did not at present justify it in takin

over any premises in their entirety. The opportunity presented itself early in 1938 of renting space in the new Adelphi building, then in course of erection. Through the generous financial assistance of certain oil companies, the Council was enabled to take advantage of this opportunity, and concluded a seven years' lease of premises in the Adelphi.

The Institute entered into possession of its new headquarters in October 1938. The offices are situated on the sixth floor, in the North-West Block. They comprise a large Library and Members' Room (used also for meetings of the Students' Section and Groups); a Council and Committee Room; General Office; and offices for the Secretary and Librarian.

The situation of the Adelphi has many advantages. One entrance is directly opposite the Royal Society of Arts, where Ordinary Meetings of the Institute continue to be held. The Adelphi is readily accessible by Underground or bus from all parts of London. The building itself possesses architectural dignity combined with the amenities of a modern office building.

Older members of the Institute will note with interest that the site of the new headquarters almost coincides with No. 5 John Street, which was the home of the Institute from 1919 to 1923.

Meetings of the Institute.

Seven Ordinary Meetings of the Institute were held in London during 1938. In addition, a Special General Meeting and the Annual General Meeting were held on 22nd March, 1938.

The Conference in Scotland from 6th–10th June, and the Conversazione on 8th November are referred to in more detail later in this Report.

The Subjects of Papers presented at the Ordinary Meetings and their authors are given below :—

Date.	Subject.	Authors.
11th Jan.	"The Application of Automatic Control to Refinery Process Operations."	S. W. Adey.
8th Feb.	"Air-Raid Precautions in connection with Refineries and Storage of Petroleum."	Lt.-Col. R. A. Thomas.
22nd March.	Special General Meeting. Annual General Meeting.	
12th April.	Presidential Address. Presentation of Redwood Medal.	Lt.-Col. S. J. M. Auld.
10th May.	"Changes Occurring in Lubricating Oils."	Prof. H. Weiss and Dr. A. Maillard.
6th–10th June	Conference in Scotland on Oil Shale and Cannel Coal.	
11th Oct.	"Manufacture of Cutting Oils."	J. F. Miller.
	"Cutting Fluids and the Machine Tool."	A. H. Lloyd and H. H. Beeny.
	"Selection of Cutting Fluids."	H. J. Mason.
	"Function of Cutting Fluids."	Prof. H. W. Swift.
	Inauguration of Lubrication Group.	
8th Nov.	"The Search for Oil in Britain." Conversazione.	G. W. Lepper.
13th Dec.	"Some Application of Asphaltic Bitumen in Industry."	J. S. Jackson.
	Inauguration of Asphaltic Bitumen Group.	

The average attendance at these Meetings (excluding the Conversazione and the Scottish Conference) was 98. This is a very satisfactory increase as compared with an average of 78 in 1937 and 67 in 1936.

In addition to the above, a joint meeting was held with the Road and Building Materials Group of the Society of Chemical Industry on November 1st, when Dr. Ing. F. J. Nellensteyn presented a Paper on "The Rôle of Surface Tension in Bituminous Substances."

Conversazione and Exhibition.

A Conversazione was held to mark the inauguration of the Institute of Petroleum on Tuesday, 8th November, at the House of the Royal Geographical Society by courtesy of the Council of that body. The attendance at this function was 500, including ladies. The guests were received by the President and Mrs. Auld.

Capt. H. F. C. Crookshank, M.P., Secretary for Mines, opened the formal meeting, and paid a high tribute to the work and achievements of the Institute. During the course of the evening Mr. G. W. Lepper lectured on "The Search for Oil in Britain," dealing with the subject from the geological, historical and legislative aspects.

An exhibition, illustrative of geological and geophysical methods of exploration and of the progress of drilling in Britain, was arranged for the Conversazione by Messrs. the Anglo-Iranian Oil Company, the Anglo-American Oil Company, Steel Bros., and the Gulf Oil Exploration Company. The exhibition was subsequently transferred to the Institute's premises at the Adelphi, and remained open for three weeks.

Annual Dinner.

The Twentieth Annual Dinner was held at Grosvenor House, Park Lane, W.1, on Monday, 12th December, and was attended by a record number (over 300) of members and guests. The Chair was occupied by the President.

The Rt. Hon. Lord Cadman, G.C.M.G., proposed the toast of "His Majesty's Government," to which Sir Kingsley Wood, P.C., M.P., Secretary of State for Air, responded. The toast of "The Institute of Petroleum" was proposed by The Rt. Hon. Lord Stamp, G.C.B., and replied to by the President.

Branch Lecture.

Mr. G. W. Lepper, A.R.C.S., B.Sc., Technical Adviser, H.M. Petroleum Department, accepted the invitation of the Council to deliver the Branch Lecture for the Session 1938–39. The subject of the lecture was "The Search for Oil in Britain." It was delivered in the first instance in London on 8th November, and repeated in Swansea on 27th January, 1939; in Glasgow on 16th February; in Manchester on 9th March, and in Birmingham on 10th March.

Conference on Oil Shale and Cannel Coal.

The first international Conference on oil shale was organized by the Institute, and held in Scotland from 6th–10th June, 1938. It was attended by about 300 members, including official delegates and representatives from Australia, Canada, Estonia, France, Germany, Japan, Sweden and U.S.A.

In the organization of the Conference the Institute received the co-operation of the principal institutions and societies associated with the fuel

and chemical industries of Great Britain, and of the various European scientific societies connected with petroleum.

The Conference received the distinguished patronage of members of H.M. Government, and of eminent authorities representing civic, educational and industrial interests.

The Conference was held at the time of the Empire Exhibition in Glasgow. The Lord Provost and Corporation of the City of Glasgow gave a civic reception to the members and their ladies on 9th June. A detailed account of other functions and works visits during the week of the Conference has been given in the report of the *Proceedings*, "Oil Shale and Cannel Coal," published by the Institute in December 1938, to which reference is made below. This volume contains the 32 Papers presented to the Conference, together with the discussions thereon.

The Council records its appreciation of the great help afforded by Captain W. H. Cadman, B.Sc., F.I.C., M.I.Chem.E., in the task of co-ordinating the organization of the Conference with such success.

Publications.

The Journal.

Vol. XXIV of the *Journal* was published throughout 1938 as "The Journal of the Institution of Petroleum Technologists," notwithstanding the change in name of the Institute in April. The title was retained to avoid confusion in bibliographical reference.

The volume contained 8 Papers presented at meetings of the Institute held in London; 3 Papers presented to Branches of the Institute; and 33 contributed articles. The Abstracts Section of the *Journal* contained 1469 abstracts of technical literature and patents.

Two Papers sponsored by the Institute and presented to a Sectional Meeting of the World Power Conference in Vienna, August 1938, were also included in the Journal (*J.I.P.T.*, **24**, 621–641).

"*Annual Reviews of Petroleum Technology*," *Vol. III.*

The third volume in the series of *Annual Reviews* of progress in petroleum technology was issued in August. The book was considerably larger than its predecessors, and contained additional chapters on "Production Engineering" and "Aero Engines." An outstanding review of developments in Cracking and Polymerization was contributed by Dr. G. Egloff.

The Abstracts Sub-Committee which nominates the authors of the various chapters in the *Annual Reviews* has arranged that the same author shall be invited to deal with a particular subject for three successive years.

The *Annual Reviews* are becoming widely known in the petroleum industry. Their authoritative and comprehensive character renders them invaluable as a work of reference to the increasing volume of technical literature.

Oil Shale and Cannel Coal.

The *Transactions* of the Conference on Oil Shale and Cannel Coal were published by the Institute in December, as a volume of 492 pages distinct from the *Journal* and *Annual Reviews*. Captain H. F. C. Crookshank, M.P.,

Secretary for Mines, contributed a foreword to the book, from which the following passage is quoted :—

> "The Institute of Petroleum is to be congratulated on rendering yet another service to the world of science and industry, and it affords me great pleasure to commend this record of the transactions at the Conference to all who have a share in the fuel economy of our country."

The volume contains the 32 Papers presented at the Conference. It constitutes a complete review of the present state of knowledge regarding the geology, mining, treatment, and utilization of oil shale and cannel coal in all countries where these materials occur.

Standardization.

Chemical Standardization Committee.

Two revisions of methods of test were published during 1938, viz. :—

Ignition Quality of Diesel Fuels (Tentative) (*J.I.P.T.*, **24**, 176–179);
Sampling Asphaltic Bitumen in Packages (Tentative) (*ibid.*, pp. 348–349),

in addition to a Report by the Diesel Oil Panel on the Calibration of I.P.T. Diesel Reference Fuels in terms of Cetane and Cetene Numbers.

International Standards Association.—The Chemical Standardization Committee has dealt with technical questions referred to it by the British Standards Institution in connection with the work of I.S.A. Committee 28 (Petroleum Products). During the year the following methods of test have been the subject of consideration by the Chemical Standardization Committee—distillation, water in petroleum products, burning tests for kerosine, viscosity, and nomenclature (products).

Engineering Standardization Committee.

The Engineering Standardization Committee has been represented on committees of the British Standards Institution dealing with oil-well cement, pipe-threads and fittings, identification of pipe-lines, and containers for inflammable liquids.

Branches and Groups.

The Annual Reports of the activities of the Trinidad, Rumanian, Northern, and South Wales Branches are appended. Reports from the other Branches will be published in the *Journal* as they are received.

Scottish Branch.—A direct outcome of the Conference on Oil Shale and Cannel Coal was the formation of a Scottish Branch of the Institute at the end of 1938. Mr. R. Crichton has been elected first Chairman of the Scottish Branch, and Prof. W. M. Cumming its first Honorary Secretary. The Branch was formally inaugurated by the President at a meeting in Edinburgh on 20th January, 1939.

Formation of Groups.—The Council has initiated a policy of providing for the specialized requirements of members by the formation of Groups. Two such Groups were inaugurated in 1938—a Lubrication Group (Chair-

THE ADELPHI FROM THE EMBANKMENT.

[*To face p.* 300.

ENTRANCE CORRIDOR.

COUNCIL AND COMMITTEE ROOM.

MEMBERS' ROOM AND LIBRARY.

SECRETARY'S OFFICE.

LIBRARIAN'S OFFICE AND PERIODICALS ROOM.

man: Mr. E. A. Evans) and an Asphaltic Bitumen Group (Chairman: Mr. J. S. Jackson).

Meeting of Members in U.S.A.—The Fourth Annual Meeting of members in U.S.A. was held in Chicago on 16th November, under the Chairmanship of Dr. J. Bennett Hill. Following the Annual American Members' Dinner, five short talks were given by the following speakers: Dr. G. Egloff, Dr. F. H. Lahee, Mr. T. Whasson, Dr. E. C. Williams, and Mr. W. B. Wray.

Library.

The removal of the Institute's library from Aldine House to the Adelphi was made the occasion of an elimination of certain redundant and duplicate books, pamphlets, and Proceedings. Certain of these were presented to the libraries of the Royal School of Mines, Birmingham University and Leeds University. Cataloguing of pamphlets, maps, and trade literature has been completed.

During the year 323 books were loaned to members, as compared with 403 books in 1937. This reduction is due to the fact that the library books were not available for several weeks in September and October, whilst they were being transferred to the Adelphi.

The following periodicals have been added to the list of those regularly taken by the library during the year:—

Argentine.	*Anales del Instituto de investigaciones cientificas y technologicas.*
Canada.	*Canadian Chemistry and Process Industries.*
France.	*Chimie et Industrie.*
Germany.	*Beiträge zur angewandten Geophysik.*
Italy.	*La Strada.*
Poland.	*Kopalnictwo Naftowe w Polsce.*
	Przeglad Chemiczny.
	Przemysl Naftowy.
United Kingdom.	*Automobile Engineer.*
	Transactions of the N.E. Coast Inst. of Engineers and Shipbuilders.
	Science in Parliament.
U.S.A.	*O'Shaughnessey's Oil Bulletin.*

The Council records its thanks to the various Government departments, authors, and publishers who have generously presented publications to the library.

Research.

Two grants were made during the year from the Research Fund of the Institute, viz.:

To Dr. G. M. Dyson, Ph.D., F.I.C., M.Inst.Pet., Loughborough Technical College, a further grant of £10 17*s*. 6*d*. in aid of a research to investigate the effect of metallic detritus on the oxidation of mineral lubricating oils.

To the British Electrical and Allied Industries Research Association, a grant of £25 in aid of investigations on the Creep and Corrosion of Steel at High Temperatures. The major portion of this research work is being carried out at the National Physical Laboratory.

In conjunction with the National Physical Laboratory the Research

Committee has made arrangements for the supply of four typical "reference" lubricating oils for research purposes.

Awards.

The Redwood Medal of the Institute was awarded to Dr. A. E. Dunstan, D.Sc., F.I.C., F.C.S., Past-President, and Honorary Editor of the *Journal*. The presentation was made by the President at the Royal Society of Arts on April 12th.

Two scholarships of £40 each, tenable by Students of the Institute at the Universities of London and Birmingham for the year 1938–39, were awarded to J. D. Dewhurst (Royal School of Mines) and A. B. Horne (Department of Oil Engineering and Refining, Birmingham University), respectively.

The Council has instituted a Branch Prize of value three guineas, to be awarded to the member who, in the opinion of the local Committee of each Branch, has done most to foster the development of the Branch. The Prizes were awarded in 1938 to E. J. Horley (South Wales Branch) and J. E. Bennion (Northern Branch).

Council, Officers, and Committees.

Ten meetings of the Council and 29 meetings of Committees of the Council were held during the year. In addition, 10 meetings have been held of various sub-committees of the Chemical Standardization Committee.

The following Committees of the Council have met during the year:

Awards Committee: *Chairman*—The President.
Benevolent Fund Committee: *Chairman*—Dr. A. E. Dunstan.
Branch Committee: *Chairman*—Mr. C. Dalley.
Chemical Standardization Committee: *Chairman*—Prof. J. S. S. Brame.
Congress Committee: *Chairman*—Mr. J. Kewley.
Election Committee: *Chairman*—Mr. J. McConnell Sanders.
Finance Committee: *Chairman*—Mr. C. Dalley.
House Committee: *Chairman*—Mr. Arthur W. Eastlake.
Library Committee: *Chairman*—Prof. J. S. S. Brame.
Publication Committee: *Chairman*—Dr. A. E. Dunstan.
Research Committee: *Chairman*—Mr. J. Kewley.

The Council has delegated the detailed work of preparation of the *Journal* and other publications to a small Publication (Executive) Committee consisting of Dr. Dunstan, Dr. Garner, the Secretary, and Assistant Secretary.

Professor A. W. Nash, M.Sc., M.I.Mech.E., has been elected President for the year 1939–40, and will take office at the Annual General Meeting on 27th April, 1939.

Mr. Ashley Carter, Mr. C. Dalley, Dr. F. H. Garner, Mr. J. McConnell Sanders, and Dr. F. B. Thole have been elected Vice-Presidents for the year 1939–40.

The following were elected members of Council as a result of the ballot declared at the Annual General Meeting on 22nd March, 1938: Mr. A. F. Dabell, Prof. V. C. Illing, Dr. E. R. Redgrove, Mr. W. J. Wilson, and Mr. C. W. Wood.

The Council records its appreciation of the services to the Institute of the Rt. Hon. Lord Plender, G.B.E., Honorary Treasurer; Messrs. Price, Waterhouse & Co., Auditors; and to Mr. T. Outen of Messrs. Ashurst, Morris, Crisp & Co., Solicitors, upon whom fell the burden of the detailed legal work involved in the change to "The Institute of Petroleum."

Approved for publication on behalf of the Council of the Institute.

S. J. M. AULD, President.
ARTHUR W. EASTLAKE, Honorary Secretary.
S. J. ASTBURY, Secretary.

THE INSTITUTE

REVENUE ACCOUNT FOR THE

	£	s.	d.	£	s.	d.	1937 £
To Administration Expenses :—							
Staff Salaries				1616	10	7	*1648*
Printing and Stationery				281	8	6	*221*
General Postages				254	7	7	*221*
Telephone, Cables and Telegrams				27	17	0	*32*
						2180 3 8	
„ Establishment Charges :—	£	s.	d.				
Rent and Rates	1133	18	2				
Less Grant in aid of Rent (Proportion)	533	6	8				
				600	11	6	*448*
Cleaning and Lighting				75	10	0	*88*
Repairs and Renewals				44	13	0	*22*
						720 14 6	
„ Publications :—							
Journal Printing				1507	19	9	*1411*
Abstractors' Fees				253	11	0	*216*
Postage on Journals				185	10	3	*186*
Cost of Other Publications				907	0	9	*252*
						2854 1 9	
„ Meetings :—							
Hire of Hall, Preprints, Reporting				165	8	6	
Conversazione and Annual Dinner				176	8	4	
Scottish Conference	515	9	3				
Less Registration Fees Received	396	3	8				
				119	5	7	
						461 2 5	*265*
„ Professional Fees :—							
Legal Expenses				146	16	4	*80*
Auditors' Fee				42	0	0	*42*
						188 16 4	
„ Students' Scholarships						80 0 0	*80*
„ Library Expenditure						59 19 0	*46*
„ Branches and Sections :—							
Students Section				39	0	5	*30*
Trinidad Branch				40	0	0	*40*
Burma Branch				6	0	0	*18*
Branch Prizes				6	6	0	—
Sundry Expenses				2	12	3	*24*
						93 18 8	
„ Sundry Expenses						164 11 2	*195*
„ Depreciation of Office and Library Furniture and Library Books						12 12 4	*107*
„ Expenses in connection with the Adelphi : Legal, Removal, Installation, Furniture, etc.						906 11 10	
						£7722 11 8	

RESEARCH FUND INCOME AND EXPENDITURE

	£	s.	d.
To Grants Made During Year	35	17	6
„ Balance as at 31st December, 1938	213	7	8
	£249	5	2

OF PETROLEUM.

YEAR ENDED 31ST DECEMBER, 1938.

	£	s.	d.	£	s.	d.	1937 £
By **Subscriptions for 1938 Received :—**							
Members	2110	1	0				*2010*
Associate Members	1235	16	6				*1179*
Students	88	4	0				*66*
Associates	163	16	0				*171*
	3597	17	6				
Special	20	0	0				*20*
				3617	17	6	
„ **Subscriptions in Arrear Received During Year**				156	18	0	*145*
„ **Publications**				2921	16	0	*2514*
„ **Interest and Dividends, Gross**				212	6	6	*195*
„ **Balance,** being Deficit for Year carried to Balance Sheet				813	13	8	
				£7722	11	8	

ACCOUNT FOR THE YEAR ENDED 31ST DECEMBER, 1938.

	£	s.	d.
By **Balance as at 31st December, 1937**	239	3	5
„ **Interest Received During Year**	10	1	9
	£249	5	2

THE INSTITUTE

(A Company limited by Guarantee

BALANCE SHEET AS

	£ s. d.	£ s. d.	£ s. d.
Capital of the Institution under Bye-Law Section 6, Paragraphs 14 and 15 :—			
Life Membership Fund—			
As at 31st December, 1937 . .	718 10 0		
Additions during year . . .	44 5 0		
		762 15 0	
Entrance Fees—			
As at 31st December, 1937 . .	3018 14 0		
Additions during year . . .	153 6 6		
		3172 0 6	
Profit on Sale of Investments—			
As at 31st December, 1937 . .		351 10 11	
Donations—			
As at 31st December, 1937 . .		326 5 0	
			4612 11 5
Research Fund			213 7 8
T. C. J. Burgess Prize Fund . .			10 0 0
Members' Subscriptions Received in Advance			221 10 0
Journal Subscriptions Received in Advance			543 13 5
Sundry Creditors—General Account .			1364 9 4
World Petroleum Congress . . .			184 16 3
Revenue Account :—			
Balance as at 31st December, 1937 . .		2605 2 6	
Less Deficit for year as per separate Statement		813 13 8	
			1791 8 10

C. DALLEY, Chairman, Finance Committee.
S. J. ASTBURY, Secretary.

£8941 16 11

AUDITORS'

We report to the Members of THE INSTITUTE OF PETROLEUM that we have obtained all the information and explanations we have required. We are of opinion view of the state of the Institute's affairs at 31st December, 1938, according to the of the Institution.

3, FREDERICK'S PLACE,
OLD JEWRY, LONDON, E.C. 2.
18*th April*, 1939.

OF PETROLEUM.

and not having a Share Capital.)

AT 31ST DECEMBER, 1938.

	£	s.	d.	£	s.	d.
Investments :—						
On Account of Capital—						
£461 12 0 3% Conversion Stock (1948/53) . .	491	12	6			
664 6 6 3% London County Consolidated Stock .	481	10	6			
806 8 3 3% Manchester Corporation Stock 1958 .	845	17	7			
867 8 6 2½% Bristol Corporation Redeemable Stock 1955/65	845	17	7			
150 0 0 5% Wandsworth District Gas Co. Debenture Stock	154	8	6			
400 0 0 3% Metropolitan Water Board "A" Stock 1963	346	10	7			
125 0 0 5% Great Western Railway Co. Consolidated Preference Stock . . .	105	4	9			
150 0 0 3% Luton Corporation Redeemable Stock 1958	151	6	7			
150 0 0 3% Smethwick Corporation Redeemable Stock 1951/8	151	4	9			
600 0 0 3% Bristol Corporation Redeemable Stock 1958/63	597	7	3			
				4171	0	7
(Market Value at 31st December, 1938, £3975 4*s.* 5*d.*)						
On Account of Revenue—						
£790 8*s.* 3*d.* 3% Conversion Stock	842	8	0			
On Account of Research Fund—						
£336 5*s.* 6*d.* 3% Conversion Stock	357	14	8			
				1200	2	8
(Market Value at 31st December, 1938, £1112 10*s.* 5*d.*)						
Office and Library Furniture (Excluding Presentations) :—						
As at 31st December, 1937	198	4	0			
Less: Sales and Depreciation	18	4	0			
				180	0	0
Library Books (Excluding Presentations) :—						
As at 31st December, 1937	23	8	4			
Less: Depreciation	3	8	4			
				20	0	0
Members' Subscriptions in Arrear (not valued).						
Sundry Debtors and Payments in Advance :—						
Sundry Debtors, less Reserve for Doubtful Accounts .	428	13	0			
Payments in Advance	237	10	2			
				666	3	2
Cash at Bank and in Hand				42	11	4
Cash on Deposit, General Account :—						
Chartered Bank of India, Australia and China . .	500	0	0			
Post Office Savings Bank	2002	13	4			
World Petroleum Congress Account	159	5	10			
				2661	19	2
				£8941	16	11

REPORT.

examined the above Balance Sheet with the books of the Institute and have that such Balance Sheet is properly drawn up so as to exhibit a true and correct best of our information and the explanations given to us and as shown by the books

PRICE, WATERHOUSE & Co.

BENEVOLENT FUND.

RECEIPTS AND PAYMENTS ACCOUNT FOR YEAR ENDED 31ST DECEMBER, 1938.

RECEIPTS.	£ s. d.	£ s. d.	PAYMENTS.	£ s. d.	£ s. d.
Balance on Current and Deposit Accounts on 1st January, 1938 :—			**Grants in Aid :—**		
Benevolent Fund Account	654 5 7		Benevolent Fund	42 0 0	
Specific Endowment Fund	174 13 2		Specific Endowment Fund	133 6 8	
		828 18 9			175 6 8
Receipts during 1938 :—			**Cheque Stamps**		8 4
Benevolent Fund:			**Balance on 31st December, 1938 :—**		
Donations	50 6 11		Benevolent Fund	718 15 7	
Subscriptions	46 4 6		Specific Endowment Fund	43 2 11	
Interest (nett)	10 6 11				761 18 6*
		106 18 4			
Specific Endowment Fund:					
Interest (nett)		1 16 5			
		£937 13 6			£937 13 6

* The Balance on Current and Deposit Accounts and Invested on 31st December, 1938, was made up as follows :—

	£ s. d.
Cash at Bank	33 1 6
Deposit Account	200 0 0
£600, 3% Local Loans (at cost)	528 17 0
	£761 18 6

We have examined the above Receipts and Payments Account with the books and vouchers of the Fund and find it to be in accordance therewith. We have verified the Balances with Bankers.

3, FREDERICK'S PLACE,
OLD JEWRY, LONDON, E.C. 2.
18*th April*, 1939.

PRICE, WATERHOUSE & Co.

TRINIDAD BRANCH.

Report of the Committee on the Working of the Branch during the Session 1937–1938.

SEVEN meetings were held during the session, at which the following papers were read :—

1st December, 1937.	10th Annual General Meeting. " Accelerated Oxidation as a Control Test in the Treatment of Cracked Gasoline," A. Newton.
26th January, 1938.	" Rotatory Rig Drives Powered by Internal-Combustion Engines," C. R. Massy.
23rd February, 1938.	" Oil Well Pumping," P. E. T. O'Connor.
23rd March, 1938.	" Steel : its Manufacture and Special Uses," C. H. Hayward.
11th May, 1938.	" A Laboratory Method for Evaluating Crude Oil," R. Edgeworth Johnstone and R. Palmer.
1st June, 1938.	" Notes on Seismic Deflection Methods," E. P. Van der Linden.
22nd June, 1938.	" A Visit to Russian Oil Districts," Dr. H. G. Kugler.

The average attendance of members and guests at meetings was 30.

There were 76 members on the roll at the end of the year.

Mr. J. L. Harris was elected Chairman, and Mr. W. N. Foster was elected Honorary Secretary and Treasurer for the session.

The Annual Dinner, which would have been held in October, was postponed to December, owing to the illness of His Excellency the Governor, who had accepted the Committee's invitation to be present. It was again postponed to 14th January, 1939, as His Excellency the Acting Governor could not attend due to Court mourning.

An epidiascope was purchased during the year, and was first used for Dr. Kugler's paper.

J. L. HARRIS,
Chairman.

W. N. FOSTER,
Hon. Secretary.

28*th November*, 1938.

TRINIDAD BRANCH.

Accounts for the Year ended 31st October, 1938.

REVENUE ACCOUNT.

Stenographer's remuneration	$ 47.00	Quarterly grants from London	$192.00
Epidiascope and box	197.33	Excess of expenditure over income	99.74
Cost of draft on London	.30		
Postage, printing, etc.	47.11		
	$291.74		$291.74

BALANCE SHEET.

Surplus brought forward	$277.41	Balance at Bank	$270.66
Less Deficit for year	99.74	Cash in hand	8.15
	$177.67		
Sundry Creditors	$101.14		
	$278.81		$278.81

(*Sd.*) J. L. HARRIS, *Chairman.*

W. N. FOSTER, *Hon. Secretary and Treasurer.*

(*Sgd.*) C. MIDDLETON, D. M. WALSH } *Auditors.*

ROUMANIAN BRANCH.

Annual Report, 1938.

THE Committee of the Roumanian Branch has pleasure in presenting the Twelfth Annual Report for the Session 1938 together with Accounts for this period.

The Branch Register shows the following list of Members :—

Honorary Members . . .	1
Members	22
Associate Members . . .	12
	35

which is a decrease of 10 as compared with a year ago.

The Eleventh Annual General Meeting was held on 17th April, 1938, at which the Chairman, Mr. E. C. Masterson, retired, and was succeeded by Mr. I. S. Rutherford.

Four General Meetings were held during the year and the following papers were read :—

7th April, 1938.	"Principles of Rational Exploitation," C. A. Dimitriu.
12th May, 1938.	"Safety," C. B. Stults.
9th June, 1938.	"Drilling Muds," M. Constantinescu.
8th December, 1938.	"Directional Drilling," C. A. Brokaw.

The Twelfth Annual Dinner was held on 14th January, 1939, under the Chairmanship of Mr. I. S. Rutherford, and 85 Members and Visitors were present.

A copy of the audited Statement of Accounts for the 1938 Session is given below.

The following is a list of the Members of the Committee of the Roumanian Branch.

Officers.

Chairman—Mr. I. S. RUTHERFORD.
Secretary and Treasurer—Mr. O. A. BELL.

Committee.

Mr. E. C. MASTERSON.
Mr. D. I. MAXWELL.
Mr. L. W. FORSTER.
Mr. I. EDELEANU.
Mr. P. R. CLARK.
Capt. J. E. TREACY.
Mr. C. R. YOUNG.
Mr. G. PRIKEL.

The Committee again wish to record their thanks to the Chamber of Commerce, Ploesti, for the use of their Hall for the meetings during the 1938 Session, and to Messrs. Brasier and Suciu for acting as Honorary Auditors.

I. S. RUTHERFORD, *Chairman.*

O. A. BELL, *Hon. Secretary.*

Receipts and Payments for the 1938 *Session (up to and including* 15*th January,* 1939).

Receipts.

Balance from 1937 Session	Lei 7014
Sundry Receipts	,, 900

Expenditure.

Cost of Meetings, Printing, Postage, and Chamber of Commerce	Lei 1725	
General Stationery and Postage London	,, 230	
Administration Expenses	,, 2200	
Annual Dinner, Printing and Postage of invitations, Menu Cards and Gratuities	,, 2441	
Balance in Hand	,, 1318	
	Lei 7914	Lei 7914

We have verified the above Receipts and Payments Account with the books, records, vouchers, and other documents of the Roumanian Branch of the Institute of Petroleum, and having obtained all the information and explanations we have required, we are of the opinion that such account is properly drawn up to represent a true and correct statement of the receipts and payments for the period under review.

C. BRASIER
G. SUCIU } *Hon. Auditors.*

NORTHERN BRANCH.

Report, Session 1938–1939.

Membership.

Members of Parent Institute . .	79
Branch members only . . .	178
	257

Officers.

Chairman : Mr. A. McCULLOCH.
Deputy Chairman : Mr. J. CUTHILL.
Hon. Treasurer : Mr. E. J. DUNSTAN.
Hon. Secretary : Mr. J. ERIC HASLAM.

Committee.

Mr. H. C. S. FOTHERGILL.
Mr. J. S. PARKER.
Mr. G. H. THORNLEY.
Mr. C. E. BURNETT.
Mr. W. T. COLLINGS.
Mr. H. O. CLAYTON.
Mr. P. M. GRIFFITHS.
Mr. T. G. PROVEST.
Mr. E. W. UNMACK.

Meetings.

Place of meeting—Engineers' Club, Albert Square, Manchester. Time—7.15 p.m.

22nd September, 1938.	Visit to Gunhill well borings by kind permission of D'Arcy Exploration Co., Ltd.
6th October, 1938.	Joint meeting with the Institute of Chemistry. "Natural Petroleum—The Deficiencies of Nature and their Rectification," Dr. F. B. Thole.
3rd November, 1938.	"Industrial Greases," R. McDonald.
8th December, 1938.	Joint meeting with North-Western Branch of the Institute of Automobile Engineers. "Light Lubricants for Automobile Engines," C. G. Williams.
5th January, 1939.	"Modern Methods Applied to the Manufacture of Lubricating Oils," J. C. Wood-Mallock. (At this meeting a presentation was made to Mr. J. E. Bennion, inaugural Hon. Secretary, on his retirement.)
19th January, 1939.	Special meeting for Ellesmere Port, Liverpool, and Birkenhead area, held at Ellesmere Port. "Modern Methods Applied to the Manufacture of Lubricating Oils," E. J. Dunstan.
9th February, 1939.	Joint meeting with the Institute of Chemistry. "What happens to Motor Oil and What Happens to the Engines," C. I. Kelly.
16th February, 1939.	Annual Dinner and Dance.
9th March, 1939.	Annual General Meeting. Branch Lecture: "The Search for Oil in Britain," G. W. Lepper.

(*Signed*) A. McCULLOCH.
Chairman.
9th February, 1939.

J. E. HASLAM.
Hon. Secretary.

Northern Branch.

Balance Sheet—January–December, 1938.

Receipts.	£	s.	d.	Payments.	£	s.	d.
Balance brought forward :				Printing and Postages	32	4	11
Bank	28	7	4	Hire of Rooms	22	17	9
Cash	6	1	7	Dinner Account	42	11	0
Subscriptions	38	8	6	Visit to Gunhill :	£	s.	d.
Preprints	9	16	0	Hotel	4	16	0
Dinner Tickets	33	15	0	N.W.R.C.C.	4	5	0
Visit to Gunhill	9	19	0				
Chemical Society	1	16	2		9	1	0
Return of cheques (Clayton)		1	2	Manchester Chemical Societies' Joint Advisory Committee	5	10	0
Bank Interest			6	*Petroleum Times* Subscription	1	19	0
				Cheque-Books		7	0
				Commission		9	0
				Bank Balance	12	4	6
				Cash in hand	1	1	1
	£128	5	3		£128	5	3

E. J. Dunstan,
Hon. Treasurer.

W. Cowan
E. Walpole } *Hon. Auditors.*

SOUTH WALES BRANCH.

Report of Committee for Year 1938.

Membership.—The membership of the South Wales Branch now stands at 85, of whom 10 are members of the parent Institute. The corresponding figures for 1937 were 84 and 6, respectively.

Meetings.—Nine Papers were read during the year at meetings, two of which were held jointly with the Chemical Society in Swansea, and one with the Institute of Chemistry (South Wales Branch).

The following is a List of Papers presented :—

14th January, 1939.	"The Production of Fischer Tropsch Spirit and its improvement by Cracking," C. S. Snodgrass and M. Perrin.
4th February, 1939.	"Crystallography," E. G. Cox. (Joint Meeting with Chemical Society.)
11th February, 1939.	"Reminiscences of Llandarcy," E. J. Horley.
18th March, 1939.	"Cracking," M. A. L. Banks.
1st April, 1939.	"Progress in Lubrication," Col. S. J. M. Auld.
8th April, 1939.	"Asphaltic Bitumen Properties and Application," A. W. Jarman.
28th April, 1939.	"Petroleum and Posterity," Dr. A. E. Dunstan.
10th November, 1939.	"Chemical Carcinogenic Agents," Dr. J. W. Cook.
9th December, 1939.	"Engine Knock and its effect on Fuel Development," Dr. Newitt.

Finance.—The Income and Expenditure Account for the year and Balance Sheet on 31st December, 1938, are given below.

Committee.—The following constitutes the Committee of the Branch for the Session 1939–1940.

Officers.

Chairman : Mr. A. E. Holley.
Vice-Chairman : Mr. R. B. Southall.
Hon. Secretary : Mr. E. Thornton.

Mr. F. V. M. Bell.
Mr. S. W. Cooke.
Mr. E. H. Ettlinger.
Mr. C. Gourlay.
Mr. E. J. Horley.
Mr. W. C. Mitchell.
Mr. W. Neville.
Mr. E. S. Squire.

South Wales Branch.

Income and Expenditure Account for Year ended 31st December, 1938.

	£	s.	d.		£	s.	d.
To Hire of room and screen	1	14	3	By Subscriptions from Branch Members	6	15	0
„ Canteen charges for tea supplied prior to lectures	3	13	0	„ *Balance*, being excess of expenditure over income, carried to Balance Sheet	2	6	5
„ Sundry expenses	3	8	8				
„ Cheque book and receipt book		5	6				
	£9	1	5		£9	1	5

Balance Sheet at 31st December, 1938.

	£	s.	d.		£	s.	d.
Balance as at 1st January, 1938	24	10	4	Cash at National Provincial Bank, Ltd., Neath	22	3	11
Less Balance transferred from Income and Expenditure Account	2	6	5				
Balance on 31st December, 1938	£22	3	11		£22	3	11

THE INSTITUTE OF PETROLEUM.

ANNUAL GENERAL MEETING.

THE TWENTY-SIXTH ANNUAL GENERAL MEETING of the Institute was held in the Lecture Theatre of the Institution of Mechanical Engineers on Thursday, 27th April, 1939, at 5.30 p.m. The Chair was taken by the President, LT.-COL. S. J. M. AULD.

THE SECRETARY read the Notice convening the Meeting and the Reports of the Auditors.

The Minutes of the Twenty-fifth Annual General Meeting were read, confirmed and signed.

BALLOT FOR COUNCIL.

THE SECRETARY announced that nine nominations had been received for six vacancies on the Council. As a result of the ballot the following had been elected: MR. G. H. COXON, DR. E. B. EVANS, MR. A. C. HARTLEY, MR. J. S. JACKSON, MR. H. C. TETT and DR. A. WADE.

NEW MEMBERS.

It was agreed that the list of Members, Associate Members, Students, and Associates elected and transferred during 1938 should be laid on the table.

ANNUAL REPORT AND ACCOUNTS.

THE PRESIDENT said that the Annual Report of the Council for the year ended 31st December, 1938, had been circulated to all the members, and it was with pleasure that he submitted it for their approval at the Twenty-sixth Annual General Meeting. He would be glad if, for the purposes of the Meeting, the Report could be taken as read. (Agreed.)

He commended to the attention of the Meeting the full and able manner in which the Report had been prepared. It clearly indicated the chief activities of the Institute during the last year. It was not his intention to summarize the summary, or again to re-state the position in regard to their recent development. Opportunity had been taken to do that on numerous occasions during the past year, and particularly at the Special General Meetings, the Annual Dinner, the inauguration of branches and groups, and the Conference held in Scotland in June. He wanted to state, however, that the optimism expressed on all those occasions regarding the changes in constitution and the activities of the Institute appeared to be fully justified. They continued to forge ahead in membership, in decentralization of their work, and he trusted in breadth of outlook as well as in breadth of interest. The membership at the end of the year was only 22 short of 1,500, a landmark which he was glad to say had since been passed.

There was one matter to which he wanted to refer under the heading of "Premises." That was to emphasize their thanks for the generous and understanding help of certain companies within the industry which had enabled them to take possession of the new and beautiful premises in the Adelphi.

On previous occasions he had made it clear that the Council regarded that aid as a temporary measure and that, at the earliest suitable moment, steps would be taken to found a Building and Capital Fund with the object in view of acquiring their own and separate premises. The Council had empowered him to take initial steps to develop that Fund, but he felt that the condition of national and international tension was not conducive to the successful launching of an effort of that kind at the present. It would be better to await, what he fervently hoped would be imminent, quieter conditions. He could assure them, however, that when the time came to make a start there was every indication that they would receive the strong and highly appreciative support of the industry.

It was with satisfaction also that he referred to the activities of the branches and groups. Especially gratifying was the formation of the Scottish branch, which was already proving itself one of their most active constituent parts. They might well be optimistic also in regard to the formation of two groups, which it might be anticipated were the forerunners of others, to meet the needs of members' interest in specialized subjects. In each case the inaugural meetings had been well attended and enthusiastic. Evidence of the continually growing enthusiasm of the members in general was shown by the largely increased attendances at the Ordinary Meetings of the Institute. An average of nearly 100 spoke for itself.

Without being self-satisfied or smug, he thought they could look back on their efforts of the last year with pride. 1938 had brought to fruition much work conceived in the past and carried out patiently and determinedly over a number of years. For that reason he was convinced that all the evidence shown of fresh outlook could be regarded also as a measure of future attainment.

In presenting the Report of Council for the year he wished to indicate to the members the labour of love which it represented on the part of ordinary Members of Council, of the Honorary Officers, and the Staff. It was impossible adequately to appraise the whole-hearted devotion of those constituent parts of the organization of the Institute, but he could assure them that the Institute had been well served. He wanted to refer particularly, however, to the able and ardent work of the Secretary, Mr. S. J. Astbury, on whom they had learnt to lean with confidence.

The Council, Officers, and Staff, on their side, continued to feel that they had the ordinary members' fullest confidence and support. That made their work so much more pleasant and efficient.

He formally moved the adoption of the Annual Report of the Council together with the Accounts for the year ended 31st December, 1938, and asked Mr. Christopher Dalley, Chairman of the Finance Committee, to deal with the accounts and to second the motion.

MR. CHRISTOPHER DALLEY, in seconding the motion, said the Accounts, which had been circulated, called for very little comment, as it was obvious that the deficit on the Revenue Account was entirely due to the fact that the whole of the expenditure on the new premises had been charged to current revenue. The valuation placed on the furniture and books had been written down on the Balance Sheet to the round figure of £200. This was sound policy, and he hoped they would be able to continue it. He

did not want it to be assumed that the expenditure on the Adelphi was finished. There were many more amenities which it was necessary to introduce into the Members' Room, which admittedly looked a little bare. The Council proposed to complete the furnishing of that room in a few months, and he hoped that members would use it to the full. The room had already proved very adaptable to the holding of small exhibitions, and the Council proposed to hold similar exhibitions of technical interest from time to time.

The Balance Sheet indicated a sound position. Although the bank balance at the end of the year was only £42 as against sundry creditors £1,364, it would be noted that the Council had taken full advantage of the facilities of investing small surpluses in the Post Office Savings Bank. There was a balance in the Post Office of £2,002. It was also a feature of Institutional finance, in contrast to ordinary commercial finance, that a large part of the Institute's income was received at the beginning of the year. In consequence, practically the whole of the £1,364 owing on the 31st December, 1938, was paid on the 1st January, 1939.

As the President had said, it was the great generosity of certain oil companies which had enabled them to move into the excellent premises at the Adelphi.

He had much pleasure in seconding the adoption of the Annual Report and Accounts.

The motion was carried unanimously.

Election of Auditors.

Mr. A. Carrick Smith proposed, Mr. T. C. R. Baker seconded, and it was carried unanimously that Messrs. Price, Waterhouse & Co. be elected Auditors for the ensuing year.

The President asked whether any member wished to raise any other business. As no other business was raised, The President proceeded to the induction of Professor A. W. Nash.

Induction of New President.

The Council had unanimously chosen as President of the Institute of Petroleum for 1939–40 Professor A. W. Nash. It was now his great pleasure to herald that decision and to lead Professor Nash to the Presidential Chair.

His eulogy of the incoming President would be brief but sincere, because the Meeting was well acquainted with his worth and exceeding fitness for that position.

At the University of Birmingham Professor Nash had developed and led a School of Petroleum Technology which had achieved outstanding success. It had had fundamental influence on the training and outlook of British Oil Technologists and had attracted students from all over the world. The high standard of investigation and research work which Professor Nash and his collaborators had carried out during the last decade or so had been the great admiration of his friends and colleagues in the petroleum industry in Great Britain. He could assure the members that

it was also fully appreciated abroad. Professor Nash's interests in that direction had been catholic. Considering that Great Britain was not an effective oil-producing country, it was significant of Professor Nash's wide knowledge and interests and his understanding of the requirements of his students, and the British petroleum industry as a whole, that so many of his investigations had dealt with practical problems ranging from oil-field to user.

Looking at Professor Nash's career, this breadth of outlook was perhaps more readily understandable, since he joined the oil industry as far back as 1909 and had subsequently extended practical experience of production both in Persia and Russia. After the War, during which he was in the service of the Air Ministry, Professor Nash had considerable general and consulting experience in petroleum. Having in 1922 been appointed lecturer in Oil Engineering and Refining at the University of Birmingham, he succeeded only two years later to the Professorial Chair—a Chair which he had distinguished by his occupancy ever since.

Professor Nash was unsparing in his work and prolific in his output. He had already left a permanent mark upon the literature of petroleum by his share as Editor of Contributions of that great work " The Science of Petroleum " which appeared last year. Text-books on Motor Fuel and Lubrication also stood to his credit. The Institute could, he was sure, look forward to Professor Nash putting into his work as President of the Institute of Petroleum the same high standard of effort which he had set himself elsewhere. They could congratulate themselves on their choice and look forward under his leadership to a continuity and development of the great work of the Institute in which they all took such a pride.

He then asked Professor Nash to occupy the President's Chair.

Professor A. W. Nash, who was received with warm acclamation, thanked Colonel Auld for the gracious manner in which he had inducted him into the Presidential Chair.

When reviewing the long and distinguished list of Past Presidents—Professor Brame, Sir Thomas Holland, Mr. Adams, Dr. Dunstan, Mr. Kewley, Mr. Dewhurst, Lord Cadman, and Colonel Auld—he appreciated the more the honour of being chosen as President. It was interesting to recall that his immediate predecessors, Lord Cadman and Colonel Auld, had carried through a great change in the constitution of the Institute and its outlook, and he asked the members to collaborate with him so that they might build worthily on the substantial foundations which had been laid.

The standard set by his predecessors in the past had been a high one, and although he would do his very best to emulate their example, he realized that the task was no easy one. In that respect he was fortified with the knowledge that he would have the help and support of a body of men, the members of the Council, whose loyalty to the Institute he had had the opportunity of witnessing and admiring for some years past.

By broadening the basis of membership he was hoping that in the future there would be papers embracing other branches of petroleum technology besides the purely scientific, and in that respect they had his assurance that he would do all in his power to uphold the dignity of the Institute

and to maintain the same high standard of such papers as had prevailed in the past.

It would also be his ambition to make the Institute of even greater usefulness to its members and to the petroleum industry. He might perhaps be allowed to touch on a point which was of particular interest to him, the Summer Meeting to be held in Birmingham in a few weeks' time. It was a happy thought of the Council that such a Meeting should be held in the city in which he had worked for so many years, and he sincerely hoped that the members of the Institute would give the Meeting their full support.

The occasion was not one which called for a long address, and he would therefore conclude by expressing his sincere thanks to the members of the Institute for the honour they had accorded to him by electing him as President.

Vote of Thanks to Retiring President.

Professor J. S. S. Brame, in proposing a Vote of Thanks to the retiring President, said it was a duty which gave him great pleasure. They all admired the tremendous energy which Colonel Auld had put into the work of the Institute. When it was remembered that during his term as President of the Institute he was also for a great part of the time President of the Oil Industries Club, it seemed marvellous that he should have found time to give to the work of the Institute in the unstinting manner in which he had given it.

People might be inclined to think the work of a President was a once-a-month job, but they had to realize what a tremendous amount of Committee work and general supervision work necessarily fell to the President of an Institute such as the Institute of Petroleum, with something like 1,500 Members. Colonel Auld had been unstinting in the amount of time and energy he had put into the work of the Institute.

In addition to the purely business side of the work, the members had to thank the President for presiding, and very ably presiding, at their social functions. The last Annual General Dinner created a record for attendance, and, if he could be allowed to say so without offending any of the Past Presidents like himself, a record in the matter of the after-dinner speech made by the President on that occasion. There was also the very happy function held at the rooms of the Royal Geographical Society. The President and Mrs. Auld had carried out most successfully the social duties attaching to that meeting.

One thing of particular importance was that Colonel Auld was really the last President elected to the Institution of Petroleum Technologists, and during his term of office there were considerable changes. It would be appreciated that great as were the normal duties of the President of such an Institute, when great changes were being made, when such things as Articles of Association, new Bye-Laws, and so on, had to be most carefully considered, sent to solicitors, returned by solicitors, and gone through by the President and Committees, the duties of the President were particularly onerous. A very special Vote of Thanks was due to Colonel Auld for his work in this connection.

Sometimes the Institute was criticized because those who had passed the Chair remained perpetual Members of Council. He was the oldest Past President present, and he therefore felt he would be forgiven if he said that that had not really operated against the Institute. Quite a number of Past Presidents had worked most strenuously from the date of laying down their office until the present time, and he had every reason to think that Colonel Auld would be among them. He hoped that for many years they would have the benefit of his advice and guidance at the Meetings of the Council.

He therefore had great pleasure in proposing a most hearty Vote of Thanks to Colonel Auld.

(*The motion was put to the Meeting by the President and carried by acclamation.*)

Colonel Auld briefly thanked the members and assured them that his term of office had been a most pleasant one.

The President then declared the Meeting closed, and the proceedings terminated at 6.5 p.m.